

PROJECT MANUAL



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ENERGY CENTER- CHILLER ADDITION **PROJECT #BI-RC-408**

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APRIL 24, 2020

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General provisions of the Contract, including General and Supplementary Conditions, General Requirements apply to the work specified in this Section.
- B. Scope of Work: This Section contains special provisions for Divisions 23.

1.2 EXAMINATION OF SITE AND DRAWINGS:

- A. Before submitting his bid, Contractor shall visit site with plans and specifications in hand, shall consult with the Engineer and shall become thoroughly familiar with all conditions under which his work will be done since he will be held responsible for any assumptions he may make in regard thereto.
- B. The Contractor shall verify and obtain all necessary dimensions at the building.
- C. Certain present building clearances are available for handling equipment. All equipment shall be delivered knocked down as necessary to clear restrictions.

1.3 INTENT:

- A. Finished Work: The intent of the specifications and drawings is to call for finished work, completed, tested and ready for operation.
- B. Good Practice: It is not intended that the drawings show every pipe, fitting or minor detail and it is understood that while the drawings must be followed as closely as circumstances will permit, the systems shall be installed according to the intent and meaning of the Contract Documents and in accordance with good practice.
- C. Work under this Section shall include giving written notice to the Agency within 15 days after the Award of the Contract of any materials of apparatus believed inadequate or unsuitable or in violation of any laws or codes, or items of work omitted. In the absence of such written notice, it is mutually agreed that work under each Section has included the cost of all required items and labor for the satisfactory functioning of the entire system without extra compensation.
- D. Any apparatus, appliance, material or work not shown on drawings but mentioned in specifications or vice versa, or any incidental accessories necessary to make the work complete and perfect in all respects and ready for operation, even if not particularly specified, shall be furnished and installed by Contractor at no additional cost to the Agency.
- E. Prior to receipt of bids, Contractors shall give written notice to Engineer of any materials or apparatus believed inadequate, unsuitable or in violation of laws, ordinances, rules or regulations of authorities having jurisdiction and any necessary items or work omitted.
In the absence of such written notice, it is mutually agreed that Contractor has included the cost of all required items in his proposal and that he will be responsible for approved satisfactory functioning of systems without further compensation.

- F. In all cases where apparatus is herein referred to in singular number, it is intended that such reference include as many such items as are required to complete work.
- G. If not otherwise specified or shown on plans, apparatus and materials shall be installed in accordance with manufacturer's published recommendations and instructions and to the complete satisfaction of the Architect.
- H. It is the intent of these specifications for Mechanical and Electrical Contractors and/or their subcontractors or equipment suppliers to furnish all equipment complete with all accessories.

1.4 REGULATIONS:

- A. Codes: All work shall be done in strict accordance with the 2018 Connecticut State Building, 2018 Connecticut State Fire Safety Code, 2015 IBC, 2015 IPC, 2015 IMC, Connecticut Public Health Code, 2015 NFPA 101, all applicable NFPA Codes, NEC, UL, NEMA, O.S.H.A., with all requirements of local utility companies and the requirements of all governmental departments having jurisdiction.
- B. Precedence: Requirements of the above Codes and Regulations that are more restrictive than requirements of the plans and specifications shall take precedence over plans and specifications. Requirements of the plans and specifications that are more restrictive than requirements of the above Codes and Regulations shall take precedence.
- C. Equipment construction standards shall be as follows: Pressure vessels shall be constructed in accordance with the ASME Code, all electrical equipment shall be UL listed and approved and conform to the N.E.C., gas equipment shall be approved by A.G.A. and conform to N.F.P.A. Codes, piping materials, fittings, valves and accessories shall be constructed in accordance with A.S.T.M. and A.N.S.I. standards for class of work involved. All equipment and materials shall be new and of domestic manufacture. All the above codes shall be referenced and dated in the Connecticut Basic Building Code.
- D. Wherever discrepancies occur between above regulations and agencies and contract drawings and specifications, the requirements of above shall take precedence, except that the contract drawings and specifications shall be minimum requirements and that contractors shall advise engineer of any required changes before proceeding with work.

1.5 APPROVED FITTINGS:

- A. No material other than that contained in the "Latest List of Electric Fittings" approved by the Underwriters' Laboratories, Inc., shall be used in any part of the work. All wiring, conduit, switches and other material for which label service has been established, shall bear the label of the Underwriters' Laboratories, Inc.

1.6 PERMITS, FEES:

- A. Include all necessary notices, obtain all permits and pay all governmental taxes, fees, and other costs. File all necessary plans, prepare all documents and obtain all necessary approvals of all

governmental departments having jurisdiction. Obtain all required Certificates of the Agency before request for acceptance and final payment for the work.

1.7 DEFINITIONS:

- A. Words "finish" or "finished" refer to all rooms and areas listed in Finish Schedule on Architect's Drawings. All rooms and areas not covered in Schedule, including underground tunnels and areas above ceilings, shall be considered not finished except as otherwise noted.
- B. The word "provide" means to "furnish and install" referenced item.

1.8 PROTECTION:

- A. Work under this section shall include protecting the work and materials of all other sections from damage by work or workmen, and shall include making good any and all damage thus caused.
- B. This section shall be responsible for work and equipment until finally inspected, tested and accepted. Protect work against theft, weather, injury or damage and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials.
- C. If so specified under the respective section, work may include receiving, unloading, uncrating, storing, protecting, setting in place and connecting up completely of any motor starters, control equipment having mechanical/electrical service connections which may be furnished by Agency or furnished under another section.

Work under this section shall include exercising special care in handling and protecting equipment and fixtures. Any of the above equipment and fixtures which are missing or damaged by reason of mishandling or failure to protect shall be replaced at no additional cost to the Agency.

1.9 EQUIPMENT SUBSTITUTIONS AND DEVIATIONS:

- A. Wherever more than one manufacturer is mentioned in specifications and drawings, any of these named are considered equally acceptable to that on upon which design was based and, providing all requirements are met, insofar as performance, space requirements, noise levels and special accessories or materials are concerned, any of those named may be included in Contractor's bid. Please refer to section 01 25 00 for additional requirements specific to substitutions.
- B. Where Contractor proposes to use an item of equipment which differs from that upon which design was based, which required any redesign of structure, partitions, foundations, piping, wiring or of any other part of Mechanical, Electrical or Architectural Layout, all such redesign, new drawings or detailing required shall be prepared by Contractor at his own expense for approval of Engineer.
- C. Where approved substitutions or deviations require a different quantity, size or arrangement of structural supports, wiring, conduit, piping, ductwork, and equipment from that upon which design was based, all additional items required by the systems shall, with the approval of Engineer, be furnished by Contractor at no additional cost to Agency.

- D. Refer to Section 012500 "Substitution Requirements" and "General Conditions of the Contract for Construction for Construction Manager At Risk Article 15 Paragraphs 15.3.1 and 15.3.2 for substitution requirements. *Requests for substitutions must be made in writing prior to bid day. No requests for substitutions will be considered afterwards.*

1.10 DRAWINGS:

- A. The, mechanical, fire protection, plumbing, electrical, structural, and architectural drawings are intended to supplement each other and are to be considered as a unit which, taken together in conjunction with the specifications, completely describes the work to be done. All drawings shall be checked to verify spaces in which work will be installed. Where headroom or space conditions appear inadequate, notification shall be given to Engineer before proceeding with installation.
- B. The Engineer may without charge, make modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work.
- C. Note that the drawings are diagrammatic and indicate the general arrangement of the Mechanical and Electrical Equipment and systems, without showing every detail and fitting.
- D. Where conflicts occur between drawings and specifications or within either, the item or arrangement of better quality, greater quality or highest cost shall be included in Contract price. Engineer shall determine the manner or item with which work shall be installed.
- E. Keep one complete set of all drawings, specifications, shop drawings and addenda on the premises at all times in good condition and available to the Engineer and Agency.

1.11 COORDINATION DRAWING SUBMITTAL:

- A. The Sheet Metal Contractor shall initiate a 1/4" or 3/8" equal to one foot composite construction drawing of all areas for all the trades. He shall provide a drawing showing his proposed ductwork installation in detail including ceiling heights, duct heights, all light fixtures, all registers and diffusers and structural steel. The drawing shall be in electronic format and shall be accessible by other contractors.
- B. All electrical distribution conduits, wires and panels and any other electrical work which may conflict with the sheet metal ducts and with piping will then be drawn on the transparency under Division 26. All waste and vent piping, water piping and rain leaders will then be superimposed by the Plumbing Contractor. The Fire Protection Contractor shall superimpose sprinkler piping.
- C. Finally all major heating and process piping shall be superimposed by the Heating Contractor.
- D. Each trade shall indicate necessary seismic restraints in accordance with later paragraph in this section.
- E. Each shall use a different color code. A coordination meeting of all parties involved is then to be held and all possible conflicts are to be resolved. The Sheet Metal Subcontractor shall then include on his original tracings, any electrical or piping work in the area of his ducts as resolved, shall have all trades sign approval of the drawing and then make eight (8) prints of each drawing for review.

- F. Contractor shall submit to the engineer 1/4" scale floor plans showing proposed locations and sizes of all floor slab penetrations for each trade. This shall include all piping, ductwork, conduit, and cable penetrations. The floor slab penetration drawings shall be subject to approval by the Structural Engineer. No work shall commence without approval from the Architect and the Mechanical and the Structural Engineer.

1.12 REVIEWS:

- A. The materials, workmanship, design and arrangement of all work installed under the Mechanical section shall be subject to the review of the Engineer.
- B. Where any specific material process of method of construction or manufactured article is specified by name or by reference to the catalog number of a manufacturer, the specifications are to be used as a guide and not intended to take precedence over the basic duty and performance specified or noted on drawings. In all cases, the specific characteristics of the equipment offered for approval, shall be indicated on the shop drawings.
- C. All component parts of each item of equipment or device shall bear the manufacturer's nameplate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc. in order to facilitate maintenance or replacement. The nameplate of a subcontractor or distributor will not be acceptable.
- D. If material or equipment is installed before it is reviewed, it shall be removed and replaced at no extra charge to the Agency if, in the opinion of the Engineer, the material or equipment does not meet the intent of the drawings and specifications.

1.13 SHOP DRAWINGS:

- A. Contractor shall submit for review shop drawings of all new equipment, materials, piping and reports in electronic format. Engineer's review of shop drawings must be completed before any equipment is purchased or any work is installed. Please refer to section 01 33 00 for additional submittal requirements.
- B. Shop drawings shall consist of manufacturer's certified scale drawings, cuts or catalog, including descriptive literature and complete certified characteristics of equipment, showing dimensions, capacity, code requirements, motor and drive testing as indicated on the drawings or specifications. Also, sheet metal fabrication drawings drawn to scale of 1/4" to the foot or larger.
- C. Certified performance curves for all pumping equipment shall be submitted for review.
- D. Samples, drawings, specifications, catalogs, etc. submitted for review shall be properly labeled indicating specific service for which material or equipment is to be used, division and article number of specifications governing Contractor's name and name of job.
- E. Catalog, pamphlets or other documents submitted to describe items on which review is being requested, shall be specific and identification in catalog, pamphlet, etc. of item submitted shall be clearly made in ink. Data of a general nature will not be accepted.

- F. Review stamp rendered on shop drawings shall not be considered as a guarantee of measurements of building conditions. Where drawings are reviewed, said review does not mean that drawings have been checked in detail. Said review does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the Contract Drawings and Specifications.
- G. Failure by the Contractor to submit shop drawings in ample time for checking shall not entitle him to an extension of Contract and no claim for extension by reason of such default will be allowed.
- H. Prior to submission of shop drawings, the Contractor shall thoroughly check each shop drawing, reject those not conforming to the specifications and indicate by his signature that the shop drawings submitted in his opinion meet Contract requirements.

1.14 QUIET OPERATION:

- A. Mechanical equipment shall operate without objectionable noise or vibration as determined by the Architect/Engineer. Noise level in any normally occupied area shall not exceed that of an NC-28 curve (noise criteria-28) as established in the latest edition of the ASHRAE Guide.
- B. Mechanical Contractor shall carry an allowance for performing sound pressure measurements in areas designated by the Agency and/or Engineer as unacceptable. Each test shall be performed on a time and material bases. Tests shall be performed after regular working hours.
- C. The Contractor shall demonstrate compliance with the design noise criteria, by measuring the sound pressure levels in octave-bands from 125Hz to 8000 Hz. Measurements shall be taken 5ft. above the floor, at four locations as directed by the Engineer. Sound pressure shall be determined as an average of these octave band readings. Contractor shall use Type 1 sound level meters with octave-band filters. Contractor shall demonstrate that the instruments used in the measuring process have been calibrated by a recognized testing facility within one year. In processing the test results, the Contractor shall follow the recommendation of ARI Standard 885-90.
- D. If objectionable noise or vibration are produced and transmitted to occupied portions of the building by apparatus, piping, or other parts of the mechanical and electrical work, changes or additions, as are necessary, shall be made to the system, as approved, without extra cost to the Agency.

1.15 PAINTING:

- A. Painting is specified elsewhere in the Specifications, under Division 09.
- B. Refer to Division 09, for color coded painting of all piping in Mechanical Rooms.

1.16 CONCRETE WORK:

- A. Concrete work is specified elsewhere in the specifications under Division 03.

1.17 EXCAVATION AND BACKFILLING:

- A. Excavating and backfilling for all mechanical and electrical work inside and outside of building shall be done in accordance with Division 31 unless otherwise specified.

1.18 CUTTING AND PATCHING:

- A. Cutting and patching shall be done in accordance with Division 01, section 01 73 29 unless otherwise specified.
- B. The General Contractor will leave all openings and built-in sleeves, etc. as required, provided he receive same with the proper information and cooperation from the Electrical and/or Mechanical Contractor in due time as the construction progresses.
All cutting of openings in walls, floors, partitions, etc. not thus provided for must, however, be done by the Electrical and/or Mechanical Contractor as required to install the work including all cutting of existing construction work, and this Contractor shall restore to its original condition any work disturbed.

1.19 TEMPORARY HEAT:

- A. Contractor is referred to Section 01 50 00, Temporary Facilities and Controls for full description of temporary services.
- B. New air distribution systems *shall not* be used for temporary heating, cooling or ventilation.
- C. Contractor shall provide extended warranties for all equipment used for temporary services.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP:

- A. All materials and apparatus used shall be new, of first class quality and shall be furnished, delivered, erected, connected and finished in every detail. No materials or apparatus used shall be discontinued or about to be discontinued items.
- B. The Engineer shall have the right to reject any part of the work in case material or workmanship is not of satisfactory quality.
- C. Any unacceptable work and material shall be replaced with acceptable work and material at no additional expense to the Agency.
- D. In case there is any doubt of the acceptability of any material, submit samples to the Engineer for approval and only definite approval in writing from the Engineer shall be evidence of such approval. Such approval shall also be subject to the satisfactory installation of the material.
- E. The work in each of these sections shall be constantly under the direction of a competent and thoroughly experienced superintendent who shall be on the premises during such period as the work is in progress. The superintendent shall familiarize himself with the work of all other trades

involved insofar as they relate to or in any way affect the work of these sections, and shall coordinate the work.

- F. Unless otherwise noted, all equipment and materials shall be installed and/or applied in accordance with the recommendations of the manufacturer of said equipment, including the performance of any tests recommended by the manufacturer.

2.2 EQUIPMENT VARIATIONS:

- A. In these specifications and on the accompanying drawings, one or more makes of materials, apparatus or appliances have been specified for use in this installation. This has been done for convenience in fixing the standard of workmanship performance of any materials, apparatus or appliance which shall be substituted for those mentioned herein shall also conform to these standards.
- B. Where no specified make or material, apparatus or appliance is mentioned, any first class product made by a reputable manufacturer may be used, providing it conforms to the requirements of these specifications and meets the approval of the Engineer.
- C. To substitute other makes of materials, apparatus or appliance, than those mentioned under the mechanical or electrical sections, a request in writing to be allowed to make the substitution shall be made only per section 23 05 00 paragraph 1.9C. This request shall be accompanied by complete plans and specifications of the substitution offered. If so requested by the Architect or Engineer, also submit samples of both the specified material or appliance and the substitute.

2.3 ELECTRIC MOTORS:

- A. All motors 1/2 h.p. and above shall be integral horsepower polyphase induction motors conforming to NEMA standards MG-1-1967 and shall be T-frame design in sizes 143 T through 445 T. Each shall be NEMA design B with minimum torque values per MG 1-12.37 and 12.38. Duty shall be continuous, ambient temperature 40 degrees maximum, allowable temperature rise for open drip-proof -90 degrees, TEFC, 80 degrees C with Class B insulation rating all per MG 1-12.42.
- B. Horsepower, speed and frame sized per MG 1-10, 32, 13.02 and 13.06a.
- C. Enclosures - open drip-proof and TEFC per MG 1-1.25, 1.26 and 1.27.
- D. All dimensions per MG 1-11.31a, 11.32a and 11.34a. All motors shall have stainless steel nameplates with NEMA voltage standards shown.
- E. Locked rotor KVA per horsepower shall be designated by proper NEMA code letter per MG 1.10.37.
- F. All motors shall be premium efficiency type with a full load efficiency range of 80 percent to 95 percent. High efficiency motor rating shall meet Northeast Utilities Energy Action Program in accordance with the following schedule:

MINIMUM NOMINAL MOTOR EFFICIENCIES

HP	OPEN DRIP PROOF			HP	TOTALLY ENCLOSED		
	MINIMUM EFFICIENCY				MINIMUM EFFICIENCY		
	1200	1800	3600		1200	1800	3600
1	82.5%	85.5%	80.0%	1	82.5%	85.5%	78.5%
1.5	86.5%	86.5%	85.5%	1.5	87.5%	86.5%	85.5%
2	87.5%	86.5%	86.5%	2	88.5%	86.5%	86.5%
3	89.5%	89.5%	86.5%	3	89.5%	89.5%	88.5%
5	89.5%	89.5%	89.5%	5	89.5%	89.5%	89.5%
7.5	91.7%	91.0%	89.5%	7.5	91.7%	91.7%	91.0%
10	91.7%	91.7%	90.2%	10	91.7%	91.7%	91.7%
15	92.4%	93.0%	91.0%	15	92.4%	92.4%	91.7%
20	92.4%	93.0%	92.4%	20	92.4%	93.0%	92.4%
25	93.0%	93.6%	93.0%	25	93.0%	93.6%	93.0%
30	93.6%	94.1%	93.0%	30	93.6%	93.6%	93.0%
40	94.1%	94.1%	93.6%	40	94.1%	94.1%	93.6%
50	94.1%	94.5%	93.6%	50	94.1%	94.5%	94.1%
60	95.0%	95.0%	94.1%	60	94.5%	95.0%	94.1%
75	95.0%	95.0%	94.5%	75	95.0%	95.4%	94.5%
100	95.0%	95.4%	94.5%	100	95.4%	95.4%	95.0%

- G. Service Factors - open-drip-proof, 1 h.p. through 200-1.15 TEFC all horsepower - 1.0.
- H. Noise level within NEMA standard MG 1-12.49.
- I. In addition to the above, all motors 1 through 20 h.p. shall be TEFC with drain holes for both horizontal and vertical positions. Each shall be equipped with deep groove double shielded ball bearings prelubricated with provisions for regreasing.
- J. Motors smaller than 1/2 h.p. shall be capacitor-start or split-phase type designed for 120 volts, single phase, 60 cycles alternating current.

2.4 ELECTRICAL MOTOR STARTERS:

- A. Motor starters and variable frequency drives (VFD'S) shall be furnished by this Contractor for motor driven equipment provided under this section. The Electrical Contractor shall install the starters and VFD'S, and shall provide all power wiring to the starters and VFD'S, and from the starters and VFD'S to the motors they control.
- B. Motor starters and VFD'S shall conform to requirements of NEC, NEMA, UL, CSA, and ANSI and shall be suitable for the required horsepower, duty, voltage, phase, frequency, service, and location. All starters and VFD'S shall be furnished in NEMA enclosures suitable for the environment in which they are to be located.

- C. All starters shall be of the same manufacture and shall be furnished in Cutler-Hammer, General Electric, Square D, or Allen Bradley.
- D. Thermal Overloads:
 - 1. All motors 1/8 horsepower or larger shall be provided with thermal-overload protection. Thermal overloads shall be melting alloy ambient temperature compensating type.
 - 2. Thermal overloads shall be sized in accordance with NEC requirements for the nameplate data of the motor(s) as actually delivered to the site.
- E. Starters for manual control of single phase motors up to one (1) horsepower furnished without integral thermal overloads shall be combination manual disconnect switch and starters with thermal overload protection for each ungrounded leg. Starters shall be inoperable if a thermal unit is removed. These starters shall be 2-pole and shall be provided with green neon pilot light and handle guard/lock-off.
- F. Starters for three phase motors shall be full voltage, circuit breaker combination magnetic starters. All circuit breaker combination magnetic starters shall include melting alloy type thermal overload protection, low voltage protection, and two (2) sets of auxiliary normally open and normally closed contacts. Thermal overload protection shall be provided in each ungrounded leg. Starters shall be inoperable if a thermal unit is removed. All circuit breaker combination magnetic starters shall be equipped with control power circuits. Provide starters with control power transformers of secondary voltage required for the control power circuitry. Provide control power transformers with primary and secondary fusing. The disconnect handle on circuit breaker combination magnetic starters shall always be in control of the disconnect device with the door opened or closed. The disconnect handle shall be clearly marked as to whether the disconnect device is "on" or "off", and shall include a two- color handle grip, the black side visible in the "off" position, and the red side visible in the "on" position.
 - 1. All circuit breaker combination magnetic starters for manual control of three phase motors shall have start-stop push buttons in the cover and shall be provided with red and green pilot lights.
 - 2. All circuit breaker combination magnetic starters for automatic or interlocking control of three phase motors shall have hand-off-automatic selector switches in the cover and shall be provided with red and green pilot lights.

2.5 ACCESS DOORS:

- A. Access doors shall be of sufficient size to permit easy replacement of complete units and all groupings of complete units and all groupings of valves and equipment shall have necessary clearance for this same purpose. Provide access doors for each valve, damper, control, fire damper, etc., not accessible (such as above a non-lift out ceiling, wall or chase). See Division 08 31 16 for detailed requirements for access doors and frames. Doors shall bear the same or greater fire rating as the wall or ceiling in which they occur. Size of doors to be determined after valves or dampers are installed and shall be of adequate size to operate same.
- B. Where access is required to dampers, valves, etc., that occur above lay-in ceilings, these access doors may be omitted, provided suitable plastic markers identifying exact location of valves, dampers, etc., on lay-in ceilings are applied directly below valve grouping and identified by a number, this number to be used as a marking on valve or damper chart. Tags shall be applied on the

ceiling grid, not on the ceiling tiles. Tag samples shall be submitted to the Architect and Engineer for approval prior to fabrication and installation of said tags.

PART 3 - EXECUTION

3.1 CONNECTING TO EXISTING UTILITIES:

- A. Connections to existing utilities that will interrupt the service to the present campus buildings or surrounding neighborhood shall be made at a time agreed upon by the Agency, Architect and Contractor.
- B. If it is necessary to make connections to existing utilities outside the regular working hours, this shall be noted on the written work order and the respective Contractor will be paid for the additional cost of labor over and above what it would cost at regular day time rates.

3.2 FREIGHT, CARTING AND RIGGING:

- A. Contractor shall pay all freight and carting charges necessary to deliver all equipment furnished under his Contract to the site and furnish all necessary rigging to properly rig and set the apparatus on the pads, foundations, frames, etc.
- B. All cranes, lifts, scaffolding, blocks and tackle, ropes and chains and other equipment necessary to rig and set the apparatus shall be furnished by the Contractor.
- C. The Contractor shall set, level and align all equipment before starting operations.

3.3 COOPERATION WITH OTHER TRADES:

- A. No piping, ducts, valves, boxes, etc., shall be installed until the entire run has been checked for clearance and the work has been coordinated between all the trades. This Contractor shall be responsible for taking his own field measurements and maintaining proper clearance from the Agency's equipment and the work of other trades, and for coordinating his work with that of other Contractors and Agency. Furnish all necessary information, dimensions, templates, etc. in order that a perfectly coordinated job will result.
- B. This Contractor shall carry out his work in conjunction with other trades and shall give full cooperation to other trades. Contractor shall furnish all information necessary to permit work of all trades to be installed in a satisfactory manner.
- C. Where space is so limited that Contractor's work shall be installed in close proximity to the work of other trades or where it is evident that Contractor's work will interfere with other trades, he shall assist in working out space conditions to make satisfactory adjustments. If required or directed by Engineer, the Contractor shall prepare composite working drawings, in addition to the coordination drawings, and sections of not less than 3/4" -1'-0" scale clearly showing how his work is to be installed in conjunction with other trades; he shall make corrections necessary to satisfactorily complete installation at no additional cost to Agency.

- D. All supports for hanging material to be connected to steel structure shall be installed prior to installation of fire proofing materials. Refer to Division 7 of the specifications.
Any damage to fireproofing caused by late installation of hanging material shall be repaired by the Fire-proofing Contractor at the expense of the Contractor responsible.
- E. The Plumbing and Heating Contractors shall give to the Electrical Contractor all information on switches, controls, pilots, etc. furnished under the Plumbing and Heating Contracts, together with makes and catalog numbers where required to permit the Electrical Contractor to leave the proper boxes to receive same. This information shall be given well in advance so that the Electrical Contractor may install his work as construction progresses. In the event that this information is not given in time to permit the Electrical Contractor to leave proper boxes, etc. as construction progresses, it shall be the responsibility of the Contractor to pay all costs of cutting and patching construction required because of this neglect.

3.4 INFORMATION FOR ELECTRICAL CONTRACTOR:

- A. Deliver to the Electrical Contractor all information on motors and controls furnished under the Mechanical Contract, together with makes and catalog numbers, to permit the Electrical Contractor to leave the proper boxes and wiring.
- B. Each electric motor of 1/2 h.p. or more shall be furnished with an automatic starter.
- C. Starters shall be furnished in type to be remotely controlled and fed from dual voltage transformer 208/460 120 volts.
- D. Starters to have overload and undervoltage protection. Starters shall be of the combination disconnect switch and starter type.

3.5 SLEEVES, INSERTS AND ANCHOR BOLTS:

- A. This section shall provide and shall be held responsible for the location and position of all sleeves, inserts, and anchor bolts required by the work. Failure to do so, which requires cutting and patching of finished work, shall be done at no additional cost to Contract.
- B. All pipes passing through floors, walls or partitions shall be provided with sleeves sized to give a minimum of 1/2" clearance between sleeve and the outside diameter of the pipe, conduit or insulation, enclosing the pipe or conduit.
- C. Sleeves through concrete floors or interior masonry walls shall be Schedule 40 steel pipe, set flush with finished wall or ceiling surfaces, but extending 2 inches above finished floors or shall be in accordance with details on drawings.

In all mechanical equipment rooms or penthouses, sleeves shall extend 6 inches above finished floor.

- D. Inserts shall be individual or strip type of steel or malleable iron construction for removable nuts and threaded rods up to 3/4" diameter, permitting lateral adjustment.

- E. Provide escutcheons on all pipes and conduits wherever they pass through floors, ceilings, walls, or partitions in finished areas. Escutcheons for pipes passing through floors shall be RITTER PATTERN AND CASTING COMPANY, No. 36A or approved equal in BrassCraft or Watts, split-hinged, cast brass type designated to fit pipe on one end and cover alcove projecting through floor on the other end.
Escutcheons for pipes shall be RITTER PATTERN AND CASTING COMPANY, No. 3A or approved equal in BrassCraft or Watts - split-hinged, cast brass, chromium plated type.

3.6 FIRE STOPPING:

- A. As specified by section 07 84 13 and as follows:
1. Firestopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies. See division 07 84 13 for additional requirements.
- B. General Description of the Work : Only tested firestop systems shall be used in specific locations as follows: Penetrations for the passage of duct, cable, cable tray, conduit, piping, electrical busways and raceways through fire-rated vertical barriers (walls and partitions), horizontal barriers (floor/ceiling assemblies), and vertical service shaft walls and partitions.
- C. References
1. Test Requirements: ASTM E-814, "Standard Method of Fire Tests of Through Penetration Fire Stops" (July 1997).
 2. Underwriters Laboratories (UL) of Northbrook, IL runs ASTM E-814 under their designation of UL 1479 and publishes the results in their "FIRE RESISTANCE DIRECTORY" that is updated annually.
 3. International Firestop Council Guidelines for Evaluating Firestop Systems Engineering Judgments
 4. Test Requirements: ASTM E 84-96, "Surface burning characteristics".
 5. All major building codes: ICBO, SBCCI, BOCA, and IBC.
 6. Test Requirements: ASTM E-119, "Fire Test of Building Construction and Materials" (UL 263)
- D. Quality Assurance
1. Firestop System installation must meet requirements of ASTM E-119, ASTM E-814, ASTM E-84-96, UL 236, UL 1479 or UL 2079 tested assemblies that provide a fire rating equal to that of construction being penetrated.
 2. Firestop Systems do not reestablish the structural integrity of load bearing partitions/assemblies, or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.

E. Submittals

1. Submit Product Data: Manufacturer's specifications and technical data for each material including the composition and limitations, documentation of UL firestop systems to be used and manufacturer's installation instructions to comply with Section 01 33 00.
2. Submit material safety data sheets provided with product delivered to job-site.

F. Installer Qualifications

1. Engage an experienced Installer who is certified, licensed, or otherwise qualified by the firestopping manufacturer as having been provided the necessary training to install manufacture's products per specified requirements.
2. FM Approved firestop systems shall be installed by FM Approved firestop contractors.

G. Products, General

1. Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.
2. Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
3. Firestopping Materials are either "cast-in-place" (integral with concrete placement) or "post installed." Provide cast-in-place firestop devices prior to concrete placement.

H. Acceptable Manufacturers

1. Subject to compliance with through penetration firestop systems (XHEZ) and joint systems (XHBN) listed in Volume II of the UL Fire Resistance Directory, provide products of the following manufacturers as identified below:
 - a. Hilti, Inc., Tulsa, Oklahoma 800-879-8000
 - b. Nelson Firestop Products.
 - c. Specified Technologies Inc.
 - d. 3M Fire Protection Products Division.

I. Materials

1. Use only firestop products that have been UL 1479, ASTM E-814, or UL 2079 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.

2. Provide a firestop system with a "F" Rating as determined by UL 1479 or ASTM E814 which is equal to the time rating of construction being penetrated.
3. Provide a firestop system with an Assembly Rating as determined by UL 2079 which is equal to the time rating of construction being penetrated.

J. Preparation

1. Verification of Conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - a. Verify penetrations are properly sized and in suitable condition for application of materials.
 - b. Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rust, laitance, release agents, water repellents, and any other substances that may effect proper adhesion.
 - c. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
 - d. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.
 - e. Do not proceed until unsatisfactory conditions have been corrected.

K Coordination

1. Coordinate location and proper selection of cast-in-place Firestop Devices with trade responsible for the work. Ensure device is installed before placement of concrete.
2. Responsible trade to provide adequate spacing of field run pipes to allow for installation of cast-in-place firestop devices without interferences.

L. Installation

1. Regulatory Requirements: Install firestop materials in accordance with UL Fire Resistance Directory.
2. Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration and construction joint materials.
 - a. Seal all holes or voids made by penetrations to ensure an air and water resistant seal.
 - b. Consult with project manager, and damper manufacturer prior to installation of UL firestop systems that might hamper the performance of fire dampers as it pertains to duct work.
 - c. Protect materials from damage on surfaces subjected to traffic.

M. Field Quality Control

1. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.
2. Keep areas of work accessible until inspection by applicable code authorities.
3. Perform under this section patching and repairing of firestopping caused by cutting or penetrating of existing firestop systems already installed by other trades.

N. Adjusting and Cleaning

1. Remove equipment, materials and debris, leaving area in undamaged, clean condition.
2. Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

3.7 ACCESSIBILITY:

- A. Locate all equipment which must be serviced, operated or maintained in fully accessible positions. Equipment shall include but not be limited to motors, controllers, switchgear, drain points, etc. If required for better accessibility, furnish access doors for this purpose. Access doors shall be selected by the Architect/Engineer to specific area finishes. Minor deviations from drawings may be made to allow for better accessibility, only if approved by the Engineer. Provide fire rated access doors in rated walls, access doors shall be provided in accordance with Section 08 31 16.
- B. In the event that any equipment is not installed to permit convenient servicing, disassemble, removal of parts, etc. the Contractor shall, at his own expense, make all corrections necessary to accomplish this.

3.8 LUBRICATION:

- A. All equipment having moving parts and requiring lubrication which is installed under this Contract, shall be properly lubricated according to manufacturer's recommendations prior to testing and operation.
Any such equipment discovered to have been operated before lubrication is subject to rejection and replacement at no cost to the Agency. Units furnished with sealed bearings are accepted.

3.9 TAGS, CHARTS AND NAMEPLATES:

- A. Each valve, control, switch, electrical panel, motor and any piece of apparatus installed under this section shall be properly identified.
- B. Each sectional shutoff valve shall have a brass tag with identifying number. Tag shall be secured to valve stem with sufficient length of copper coated jack chain to allow tag to be easily read.
- C. All other equipment, including panels and switches, shall be provided with a suitable laminated plastic nameplate fastened with screws or rivets. Small equipment labels may use a pressure sensitive tape.

- D. All nameplates and labels shall identify components by proper nomenclature and numbered according to equipment schedule or as designated.
- E. Charts shall be furnished in duplicate and shall include the valve identification number, location and purpose. One chart shall be mounted in frame with a clear glass front and secured to wall in location directed. Second chart shall be for use throughout building and shall be provided with transparent plastic closure for top and attached 8" bead chain for hanging. Holes to be reinforced with brass grommets. Tags and closures as manufactured by Seton Name Plate Corp., New Haven, Conn., or approved equal in Brady or Kolbi.

3.10 INSTRUCTIONS:

- A. Prepare written instructions frames for the proper maintenance and operation of any special equipment furnished and installed under this Contract.
- B. Personally instruct the Agency's Maintenance Staff or official representative in addition to furnishing all manuals, diagrams, etc. in the proper operation and maintenance of all equipment and piping installed under this Contract.
- C. Prepare a portfolio with all tags, operating manuals, parts lists, guarantees, etc. that are packed with all equipment furnished under this Contract and submit same to the Architect.

3.11 PIPING CODE MARKERS:

- A. All service piping which is accessible for maintenance operations, except piping in finished spaces, shall be identified with vinyl plastic color bands and legends at each branch and riser take-off, at each passage through wall, floor and ceiling, adjacent to each valve and on all pipe runs marked each 20'-0" on center.

Vinyl plastic bands shall not be used in plenum ceilings. Use self-Adhesive aluminum pipe markers or pipe stencils in plenum areas.

- B. Pipe markers to conform to A.S.A. Bulletin A-13. Where pipes are too small for legends, brass identification tags 1-1/2" in diameter with depressed 1/2" high black filled letters shall be fastened with chain. Pipe markers and tags as manufactured by the Seton Name Plate Corp., New Haven, Conn., or equal approved in Brady or Kolbi.

3.12 EQUIPMENT NOT IN CONTACT AND FURNISHED UNDER OTHER SECTIONS:

- A. Furnish all piping sheet metal connections and miscellaneous accessories, and make all closing connections to equipment furnished by other Trade Contractors and Agency; include installation of all special traps, control valves and supplies furnished with such equipment. Refer to section in which outlines equipment requirements and all other specifications sections as may be pertinent to comply with intent of this Article.
- B. Unless otherwise detailed on drawings, roughing of proper size and capacity for equipment indicated on Architectural drawings as "Future" or "NIC" shall be provided and installed in such a manner and location that future final connection can be made with a minimum of work and without cutting or patching walls, partitions, ceilings or floors.

- C. Engineers' drawings are, of necessity, schematic for special equipment as exact roughing and requirements may vary with different manufacturers. Contractor is also referred to Architectural drawings and details.
- D. Contractor shall obtain approved shop drawings of equipment being furnished for extent of final connections and exact roughing required.

3.13 CLEANING PIPING, CONDUITS AND EQUIPMENT:

- A. Thoroughly clean all piping and equipment of all foreign substances inside and out before being placed in operation.
- B. If any part of a system should be stopped or otherwise impacted by any foreign matter after being placed in operation, the system shall be disconnected, cleaned and reconnected wherever necessary to locate and remove obstructions. Any work damaged in the course of removing obstructions shall be repaired or replaced when the system is reconnected at no additional cost to the Agency.
- C. During the course of construction, all pipe and electrical conduits shall be capped in an approved manner to insure adequate protection against the entrance of foreign matter, moisture, etc.

3.13 CLEANING UP:

- A. After completion of the work, remove all waste, rubbish and other materials left as a result of operations and leave the premises in clean condition.
- B. All fixtures, equipment, etc. installed under the Mechanical and Electrical Sections shall be free of dirt, grease and other foreign material and left in perfectly clean condition and ready to use.

3.14 WARRANTY:

- A. All parts of the work and all equipment shall be guaranteed for a minimum period of 24 months from the date of substantial completion.
- B. If during that warranty period, any part of the work installed fails, becomes unsatisfactory or does not function properly due to any fault in material or workmanship, whether or not manufactured or job built, each section shall upon notice from the Agency, promptly proceed to repair or replace such faulty material or workmanship without expense to the Agency, including cutting, patching and painting or any other collateral work involved and including repair or restoration of any damaged sections of the premises resulting from such faults.
- C. In the event, that a repetition of any one defect occurs, indicating the probability of further failure, and which can be traced to faulty product design, materials or workmanship, then repairs or replacement shall not continue to be made but, the fault shall be remedied by a complete replacement of the entire defective unit.
- D. In addition to the general warranty, obtain and transmit to the Agency any guarantees or warranties from manufacturers of specialties but only as a supplement to the general warranty which will not be invalidated by same.

3.15 AGENCY'S INSTRUCTIONS AND SYSTEM OPERATION:

As specified by Section 01 77 00 and as follows:

- A. At the time of the job's acceptance by the Agency, the Contractor shall furnish one complete set of reproducible approved, certified as-built drawings to the Agency. In addition, Contractor shall furnish maintenance and operating instructions for all equipment including parts list. These instructions shall be written in layman's language and shall be inserted in a vinyl covered three-ring loose leaf binder. All the information contained in the binder shall also be copied on a CD that will accompany the printed information. The information in the binder shall be first sent to be approved by the Architect/Engineer before turning over to the Agency.
- B. Upon completion of all work and of all tests, this Contractor shall furnish the necessary skilled labor and helpers for operating the system and equipment for a period of four (4) days of eight (8) hours,. During this period, instruct the Agency or his representative fully in operation, adjustment and maintenance of all equipment furnished. Give at least forty-eight (48) hours notice to the Agency in advance of this period.
- C. Contractor shall submit Instructions on CD-ROM of on-site video.

3.16 AGENCY'S ACCEPTANCE TEST:

- A. After the various systems are complete as determined by preliminary operating tests, the Contractor shall arrange for the Agency's final acceptance tests.
- B. The Contractor shall have present at each acceptance test, representatives of the several Contractors whose work is directly or indirectly involved, with instruments as necessary to validate proper performance in accordance with the design and to include the following:
 - 1. All equipment installed and operating in accordance with manufacturer's instructions and performance guarantee.
 - 2. All systems operating in accordance with specifications.
 - 3. All distribution systems properly adjusted for distribution to equipment as specified.
 - 4. The various systems properly flushed, cleaned, and free of entrapped air and dirt.
 - 5. All motors installed with proper thermal overload protection and not operating under overload conditions as determined by ammeter readings.
 - 6. All `as built` drawings, valve charts, etc. as specified in various parts of the specifications installed and/or ready for delivery to the Agency.
- C. **THE DATE OF THE ISSUANCE OF A FORMAL CERTIFICATE OF SUBSTANTIAL COMPLETION SHALL BE THE START OF THE WARRANTY PERIOD.**

3.17 TEST:

- A. Conducting Tests: Conduct all tests called for under the various sections or as required and repair or replace any defects. Perform all tests in the presence of and to the satisfaction of the Engineer and such other parties as may have legal jurisdiction.
- B. Defective Work: The Agency shall have the privilege of stopping any of the work not being properly installed. All such defective work shall be repaired or replaced and the tests shall be repeated.
- C. Repair Damaged Work: Repair all damages resulting from tests and replace damaged materials.

END OF SECTION 23 05 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 1, General Requirements, apply to the work specified in this Section.
- B. The requirements in Section 23 05 00 shall also govern the work under this Section.

1.2 SECTION INCLUDES:

- A. Vibration isolation and seismic restraints for all mechanical and electrical system including equipment, piping, conduit and ductwork within the building.
- B. The work of this section includes but is not limited to the following:
 - 1. Vibration isolation elements.
 - 2. Equipment isolation bases.
 - 3. Piping flexible connections.
 - 4. Seismic restraints for isolated and non-isolated mechanical and electrical items.

1.3 REFERENCES:

- A. Current State of Connecticut Building Code with Amendments.
- B. SMACNA - Seismic Restraint Manual Guidelines for Mechanical Systems, most current edition.
- C. Mason Industries, Inc. Seismic Restraint Guidelines, October 2011 Edition.
- D. NUSIG : National Uniform Seismic Installation Guidelines, most current edition.

1.4 QUALIFICATIONS:

- A. Qualifications: Only firms having five years experience designing and manufacturing seismic devices shall be acceptable for work in this specification.

1.5 INTENT:

- A. It is the intent of this seismic restraint portion of the specification to provide restraint of all non-structural building system components provided in Sections 23 in Seismic Zone II. Restraint systems and devices are intended to withstand, without failure, the "G" forces detailed in the chart below:

Design Level of Acceleration At Equipment Center of Gravity Seismic Zone 2)
(Av - >0.1 to 0.19)

Elevation (feet rel. to grade level)	Rigid* Mnt'd Equip	Non-Struct. Architect Component	Flexible* Mnt'd Equip	Pipe, Duct, Cable trays, Conduit, Etc.	Life Safe. Equip
Below Grade up to 20 feet above grade	0.125 "g"	0.250 "g"	0.500 "g"	0.350 "g"	1.000 "g"
21 ft. - 300 ft.	0.500 "g"	0.550 "g"	0.750 "g"	0.650 "g"	1.000 "g"
301 ft. - 600 ft.	0.750 "g"	0.900 "g"	1.000 "g"	1.000 "g"	1.000 "g"

* Rigid mounted equipment is any equipment mounted directly to structure. Flexible mounted equipment is any equipment mounted on resilient supports, ceiling suspended, roof supported or mounted on an independent frame with any primary natural frequency below 16 Hz.

- B. Seismic restraints shall be as required by 2012 IBC, Chapter 16 and 2016 State of Connecticut Building Code with amendments.
- C. Refer to section 22 05 48 and drawings for details.
- D. Seismic Certificant and Analysis
 - 1. Seismic restraint calculations must be provided for all connections of equipment to the structure.
 - 2. Calculations to support seismic restraint designs must be stamped by a registered professional engineer licensed in the State of Connecticut.
 - 3. Analysis must indicate dead loads, derived loads, and materials used for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameters, embedment, and weld length.
 - 4. A seismic design errors and omissions insurance certificate must accompany submittals.
- E. Submit drawings showing locations of all seismic restraints for equipment and piping provided under Section 23.
 - 1. The term EQUIPMENT includes ALL non-structural components. These specifications are applicable within the facility and 5 feet outside of the foundation wall. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is a partial list; (equipment not listed is still included in this specification).

Piping
Pumps

Chiller

- F. Submittals shall include a listing of all isolated and non-isolated equipment to be restrained.
- G. Seismic restraints shall not be required for the following installations:
 - 1. Piping in mechanical rooms less than 1 1/4-inch inside diameter.
 - 2. All other piping less than 2 1/2-inch inside diameter.
 - 3. All piping suspended by individual hangers 12 inches or less in length from the top of the pipe to the bottom of the support for the hanger.

1.6 SUBMITTALS:

- A. Submit under provisions of Section 01 33 00.
- B. The submittal material shall include copies of descriptive data for all products and materials including but not limited to the following:
 - 1. Descriptive Data:
 - a. Catalog cuts and data sheets.
 - b. An itemized list showing the items to be isolated and/or seismically restrained, product type or model number to be used and loading and deflection data.
 - c. Seismic restraint calculations.
 - d. Provide Calculations signed and sealed by a Structural professional engineer licensed in the State of Connecticut verifying the design and calculations for the seismic restraining system used.
 - 2. Shop Drawings:
 - a. Drawings showing equipment base construction for each machine, including dimensions, structural member sizes, and support point locations.
 - b. Drawings showing methods of suspension, support guides for conduit, piping and ductwork.
 - c. Drawings showing methods for isolation of conduits, pipes and ductwork penetrating walls and floor slabs.
 - d. Concrete and steel details for bases including anchor bolt locations.
 - e. Number location of seismic restraints and anchors for each piece of equipment.
 - f. Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and/or pipe and duct locations.
 - g. Draw details at not less than 1 1/2" per foot scale.

1.7 GENERAL (MANUFACTURER) RESPONSIBILITIES:

- A. Contractor shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes and locations per specifications.
 - 2. Provide and install isolation systems and seismic restraints as scheduled or specified.
 - 3. Guarantee specified isolation system deflection.

4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. Substitution of "Internally Isolated" mechanical equipment in lieu of the specified isolation of this section may be acceptable provided that all specified deflections and stamped seismic calculations are supplied by the equipment manufacturer.

1.8 PROJECT RECORD DOCUMENTS:

- A. Submit under provisions of Section 01 77 00.
- B. Record actual locations and installation of vibration isolators and seismic restraints including attachment points. Provide signed and sealed record drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

- A. Basis of design is products of Mason Industries Inc. models as specified in this section.
- B. Subject to compliance with requirements provide products as specified or comparable products of one of the following:
 1. Vibration Eliminator Co.
 2. Amber/Booth Co.

2.2 SEISMIC RESTRAINT TYPES:

- A. General: Installations shall be designed to safely accept external forces of one-half "G" load in any direction for all rigidly supported equipment without failure and permanent displacement of the equipment. Life safety equipment such as (fire pumps, sprinkler piping and emergency generators) shall be capable of safely accepting external forces up to one "G" load in any direction without permanent displacement of the supported equipment. Seismic restraints shall not short circuit vibration isolation systems or transmit objectionable vibration or noise.
- B. Type I (spring mount): Shall comply with general characteristics of spring isolators having a minimum o.d. to o.h. of .8 to 1 and minimum runout of 50% to solid. Shall incorporate snubbing restraint in all directions. Shall be capable of supporting equipment at a fixed elevation during equipment erection. Cast housings shall be ductile iron or aluminum. System to be field bolted or welded to deck with 1 G acceleration capability. Mason Type SSLFH or as approved.
- C. Type II (snubber): Each corner of side shall incorporate a seismic restraint having a minimum 5/8" thick resilient pad limit stops working in all directions. Restraints shall be made of plate, structural members, or square metal tubing concentric within a welded assembly incorporated resilient pads. Angle bumpers are not acceptable. System to be field bolted or welded to a deck with 1 G acceleration capability. Mason Type Z-1011 and Z-1225.
- D. Type III (cable braces): Metal cable type with approved end fastening devices to equipment and structure.

System to be field bolted to deck or overhead structural members using two sided beam clamps to steel or appropriately designed insert for concrete. All parts of system including cables, clamps, excluding fastenings are to be single vendor furnished to assure seismic compliance. Mason Type SCB.

- E. Type IV (neoprene mount): Double deflection neoprene isolator encased in ductile iron or steel casing minimum .30 static deflection. System to be field bolted or welded to deck with 1 G acceleration capacity. Mason Type BR, RBA.
- F. Type V: Non-isolated equipment to be field bolted or welded (powder shots not acceptable) to resist seismic forces unless under 100 lb. Shear force required. Mason Type SAS, SAB.

2.3 VIBRATION ISOLATION – GENERAL:

- A. Vibration Isolation shall control excessive noise and vibration in the building due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork, or conduit. (The installation of all vibration isolation units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative.)
- B. All vibration isolators shall have either known non-deflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection can be verified.
- C. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.
- D. The theoretical vertical natural frequency for each support point, bases upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than +/- 10%.
- E. All neoprene mountings shall have a Shore hardness of 30 to 60 +/- 5, after minimum aging of 20 days or corresponding oven aging.

2.4 VIBRATION ISOLATOR TYPES:

- A. Type A: Spring isolators:
 - 1. Minimum diameter of 0.8 of the loaded operating height.
 - 2. Corrosion resistance where exposed to corrosive environment with:
 - a. Springs cadmium plated or electro-galvanized.
 - b. Hardware cadmium plated.
 - c. All other metal parts hot-dip galvanized.
 - 3. Reserve deflection (from loaded to solid height) of 50% of rated deflection.
 - 4. Minimum ¼" thick neoprene acoustical base pad on underside, unless designated otherwise.
 - 5. Designed and installed so that ends of springs remain parallel and all springs installed with adjustment bolts.

6. Non-resonant with equipment forcing frequencies or support structure natural frequencies.
 7. Mason Type SLF.
 8. When used in conjunction with seismic bracing, seismic restraint Type II shall be installed.
- B. Type B: Spring isolators shall be same as Type A, except:
1. Provide built-in vertical limit stops with minimum ¼” clearance under normal operation.
 2. Tapped holes in top plate for bolting to equipment when subject to wind load.
 3. Capable of supporting equipment at a fixed elevation during equipment erection. Installed and operating heights shall be identical.
 4. Adjustable and removable spring pack with separate neoprene pad isolation.
 5. Capable of accepting 1 G of acceleration.
 6. Mason Type SLR.
- C. Type C: Spring hanger rod isolators:
1. Spring element seated on a steel washer within a neoprene cup incorporating a rod isolation bushing.
 2. Steel retainer box encasing the spring and neoprene cut.
 3. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.
 4. Mason Type HS.
- D. Type D: Seismic Restraint, Type IV: Double deflection neoprene isolator encased in ductile iron or steel casing minimum .30 static deflection. System to be field bolted or welded to deck with 1 G acceleration capacity. Mason Type BR, RBA.
- E. Type E: Elastomer hanger rod isolators:
1. Molded unit type neoprene element with projecting bushing lining rod clearance hole.
 2. Neoprene element to be minimum 1-3/4” thick.
 3. Steel retainer box encasing neoprene mounting.
 4. Clearance between mounting hanger rod and neoprene bushing shall be minimum of 1/8”.
 5. Minimum static deflection of 0.35”.
 6. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.
 7. Mason Type HD.
- F. Type F: Combination spring/elastomer hanger rod isolators:
1. Spring and neoprene isolator elements in a steel box retainer. Neoprene double deflection type. Single deflection is unacceptable. Spring seated in a neoprene cup with extended rod bushing.
 2. Characteristics of spring and neoprene as described in Type A and Type E isolators.
 3. When used in conjunction with seismic bracing, seismic restraint Type III shall be installed.

4. Mason Type DNHS.

G. Type G: Pad type elastomer mountings:

1. ¾" Minimum thickness.
2. 50 PSI maximum loading.
3. Waffled design.
4. Deflection per pad thickness.
5. Galvanized steel plate between multiple layers or pad thickness.
6. Suitable bearing plate to distribute load.
7. Mason Type Super W.

H. Type H: Grommet type elastomer bushings:

1. One piece molded bridge bearing neoprene.
2. Washer / bushing shall surround the anchor bolt.
3. Flat washer face to avoid metal to metal contact.
4. Mason Type HG.

I. Type K: Pipe Anchors: All-directional acoustical pipe anchor consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum one-half inch thickness of heavy-duty neoprene and duck or neoprene isolation material. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material travel in either direction. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction. Isolation to be bolted or welded depending on structure. Mason Type ADA.

2.5 EQUIPMENT BASES:

A. Integral Structural Steel Base, Type B-1:

1. Reinforced as required to prevent base flexure at start-up and misalignment of drive and driven units. Centrifugal fan bases complete with motor slide rails.
2. Drills for drive and driven unit mounting template.
3. Must be utilized with seismic restraint Type I, II, or IV.
4. Mason Type M, WFB.

B. Concrete Inertia Base, Type B-2:

1. Vibration isolator manufacturer shall furnish rectangular structural concrete forms for floating foundation. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth shall be a minimum of 1/10 of the longest span but not less than 6" or greater than 14". Forms shall include minimum concrete reinforcement consisting of ½" bars or angles in place in 6" centers running ways and a layer 1 ½" above the bottom and a top layer of reinforcing steel as above for all bases exceeding 120" in one direction. Isolators shall be set into pocket housings which are an integral part of the base construction and set at the proper height to maintain a 1" clearance below the base. Bases shall be furnished with templates and anchor bolt sleeves as part of this system.

2. Must be utilized with seismic restraint Type I, II or IV.
3. Mason Type K, BMK.

2.6 FLEXIBLE CONNECTORS:

A. Elastomer Type FC-1:

1. Manufactured of Kevlar reinforcement and EPDM, both molded and cured with hydraulic presses.
2. Straight connectors to have two spheres reinforced with a molded-in external ductile iron ring between spheres.
3. Elbows shall be long radius type.
4. Rated 250 psi at 170 degrees F. Dropping in a straight line to 170 psi at 250 degrees F for sizes 1-1/2" to 12" elbows. Elbows shall be rated no less than 90% of straight connections.
5. Sizes 10" to 12" to employ control cables with neoprene end fittings isolation from anchor plates by means of 1/2" bridge bearing neoprene bushings.
6. Minimum safety factor, 4:1 at maximum pressure ratings.
7. Systems bolted to victaulic type couplings or gate, butterfly, or check valves to have a minimum 5/8" flange spacer installed between conductor and coupling on flange.
8. Submittals to include test reports.
9. Mason Type Safeflex SFDEJ.

B. Flexible Stainless Hose, Type FC-2:

1. Type 321 stainless steel braided flexible metal hose.
2. 2" pipe size and smaller: threaded carbon steel fittings.
3. 1 1/2" pipe size and larger: Class 150 carbon steel flanges.
4. Suitable for operating pressure with 4:1 minimum safety factor.
5. Flexible Metal Hose Company type DFC and MFC.

C. Unbraided Exhaust Hose, Type FC-3:

1. Low pressure stainless steel annularly corrugated.
2. Fitted with flanged ends.
3. Maximum temperature 1,500 degrees F.
4. Mason Type SDL-RF.

PART 3 - EXECUTION

3.1 GENERAL SEISMIC RESTRAINT REQUIREMENTS:

- A. Install seismic restraints in accordance with manufacturers recommendations.
- B. Seismic restraining system Type III: Install taut for non-isolated equipment and slack with 1/2" cable deflection for isolated systems.

- C. Seismically restrain all piping, conduit and ductwork with Type III or Type V seismic restraint in accordance with guidelines outlined below. Restraints which are to be used in conjunction with vibration isolators shall be Type III.
1. Carbon steel piping shall be braced at maximum 40' intervals and at turns of more than 4'. Lateral bracing at maximum 80' intervals. No-hub piping to be braced at maximum 20' intervals or maximum 40' using ½ G acceleration rated couplings.
 2. Ductwork shall be braced at maximum 30' and at every turn and duct run end. Lateral bracing at maximum 60'.
- D. Equipment mounted on housekeeping pads: Pads shall be properly doweled or expansion shielded to deck to meet acceleration criteria. Mason Type HPA.
- E. Seismic Restraints are not required for the following:
1. Piping in mechanical rooms or penthouses less than 1-1/4" O.D, except fire protection and gas piping.
 2. Piping in other areas less than 2-1/2" O.D. except fire protection and gas piping.
 3. All piping suspended by individual hanger 12" or less in length from the top of the pipe to the bottom of the support for the hanger, except fire protection piping.
 4. Electrical conduit less than 1-1/2" I.D.
- F. For overhead supported equipment, over stress of the building structure must not occur. Bracing can occur from:
1. Flanges to structural beams.
 2. Upper or lower truss chords in bar joist construction at panel points.
 3. Cast-in-place inserts or drilled and shielded inserts in concrete structures.
- G. Building seismic and/or expansion joints: Install hinged joints at piping crossing expansion joints or fire walls and anchor the piping either side per the detail provided on the contract drawings. Anchors on each end are to be capable of accepting 1.5 times the operating pressure multiplied by the projected area of the pipe. Contractor shall refer to Contract Documents for fire wall and seismic/expansion joint location.
1. Offset shall be accomplished by the annular motion of a double sphere connector (TYPE FC-1) bolted to each end of an intermediate steel pipe. Bracket each joint with hinged steel connections. Hinge shall have a pin / slot assembly on both sides. The completed assembly shall be Mason Type Safeflex SFDEJ-HE.

3.2 GENERAL VIBRATION ISOLATION REQUIREMENTS:

- A. Install isolators in accordance with manufacturer's recommendations. Vibration isolators shall not cause any change of position resulting in stresses or misalignment.
- B. Mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators.

- C. Each fan and motor assembly shall be supported on a single structural steel frame (where noted on the isolation and seismic schedule). Flexible duct connections shall be provided at inlet and discharge ducts.
- D. Provide pairs of horizontal limit springs (Thrust restraints) on fans with more than 6.0 inch static pressure, and on hanger supported, horizontally mounted axial fans where indicated
- E. Provide resiliently mounted equipment, piping, and ductwork with seismic snubbers. Each inertia base shall have minimum of four seismic snubbers located close to isolators.

Snub equipment designated for post disaster use to 0.05 inch (1.5 mm) maximum clearance. Other snubbers shall have clearance between 0.15 inch (4 mm) and 0.25 inch (7mm).]

- F. Ductwork connected to rotating equipment shall be supported with Type C or Type F isolators for the first three support points.
- G. Installation of piping vibration isolators:
 - 1. All piping, except fire protection standpipe systems, is included under this section.
 - 2. Vibration isolators shall be installed on all piping outside the shafts as follows:
 - a. Piping in mechanical rooms.
 - b. Piping connected to rotating equipment and pressure reducing stations.
 - 3. Horizontal suspended pipe 2" and smaller and all steam piping shall be suspended by Type E isolator with a minimum 3/8" deflection. Water pipe larger than 2" shall be supported by Type C or Type F isolator with minimum 1" whichever is greater.
 - 4. Horizontal pipe floor supported at slab shall be supported via Type A with a minimum static deflection of 1" or same deflection as isolated equipment to which pipe connects, whichever is greater.
 - 5. Vertical riser pipe supports under 2" diameter shall utilize Type G isolation pads.
 - 6. Vertical riser guides, if required, shall avoid direct contact of piping with building.
 - 7. Pipe anchors or guides, where required, shall utilize resilient pipe anchors, Mason Industries Type ADA, or equivalent, to avoid direct contact of piping with building.
 - 8. Isolated piping which requires sway bracing shall utilize two neoprene elements, Type G to accommodate tension and compression forces.
 - 9. Pipe extension and alignment connectors: Provide connectors at riser takeoffs, cooling and heating coils, and elsewhere as required, to accommodate thermal expansion and misalignment.

H. Pipe Isolation Schedule	PIPE SIZE - INCH (MM)	ISOLATED DISTANCE FROM EQUIPMENT
	1 (25)	120 diameters (3.0m)
	2 (50)	90 diameters (4.5m)
	3 (80)	80 diameters (6.0m)
	4 (100)	75 diameters (7.5m)
	6 (150)	60 diameters (9.0m)
	8 (200)	60 diameters (12.0m)
	10 (250)	54 diameters (13.5m)
	12 (300)	50 diameters (15.0m)
	16 (400)	45 diameters (18.0m)
	24 (600)	38 diameters (23.0m)

3.3 EQUIPMENT INSTALLATION:

- A. Requirements for installation on concrete inertia bases shall be as follows:
1. Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 1”.
 2. The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.
 3. The isolators shall be installed without raising the machine and frame assembly.
 4. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.
 5. Install equipment with flexibility in wiring connection.
 6. Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to ¼”.
 7. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators, or seismic restraints.

3.4 INSPECTION:

- A. Upon completion of the installation of all vibration isolation and seismic restraints, the manufacturer’s local representative shall visit the project job site, visibly inspect all installations and report, in writing, any and all deficiencies from the specifications. Contractor shall provide the report to the Engineer and Agency representative. Any additional corrective measures required to put the system in total compliance shall be the responsibility of the installing contractor.

END OF SECTION 23 05 48

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this Section.
- B. The requirements in Section 23 05 00 shall also govern the work under this Section.
- C. Examine all drawings and data and coordinate the work of this Section with all related and adjoining work.

1.2 SCOPE OF WORK:

- A. Provide all labor, materials, equipment and tools required to complete the work described and shown on the contract drawings.
- B. This Contractor shall measure and record all the Chilled water and condenser water flows and pressure drops for all the existing pumps and chillers.
- C. Provide TAB Report per CT High Performance Building Requirements: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 -PRODUCTS

2.1 PRODUCTS:

- A. None required.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Work shall be performed only by a firm which employs certified testing, adjusting and balancing technicians as listed by the Sheet Metal Industry National Certification Board of TAB Technicians. The work may be performed by a certified Test, Adjusting and Balancing technician who may be assisted by other TAB technicians. This firm shall provide personnel trained and experienced in system balancing. This requirement will not be waived under any condition.
- B. Before submitting system performance data for approval or acceptance, the firm shall perform all necessary tests and make all necessary adjustments as required to obtain the flow and distribution of air as called for on the Contract Documents.
- C. The balance reports shall include the names, signatures and registration numbers of the technicians assigned to the project.

- D. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- E. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- F. Examine the approved submittals for HVAC systems and equipment.
- G. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- H. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- I. Examine equipment performance data including fan and pump curves.
- J. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- K. Examine test reports specified in individual system and equipment Sections.
- L. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- M. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- N. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- O. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- P. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- Q. Examine system pumps to ensure absence of entrained air in the suction piping.
- R. Examine operating safety interlocks and controls on HVAC equipment.
- S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 ACCEPTABLE FIRMS:

- A. The following listed firms are approved to perform this work:

Environmental Testing and Balancing
James Brennan Company
Technical Associates Group, Inc.
Wing's Testing and Balancing

- B. Request to employ any other balancing and testing firm must be accompanied by a complete brochure of the firm listing previous installations successfully balanced, length of time in business, names and qualifications of employees and list of instruments available for use on the project.

3.3 HYDRONIC SYSTEMS:

- A. Prior to the start of balancing, the firm shall check the rotation of all pumps.
- B. The firm shall compile the following data for each pump insofar as they apply and shall include it on the final submittal:

PUMP DESCRIPTIVE DATA

Pump Number
System Served
Pump Size
Pump Make
Pump Horsepower
Pump impellor diameter
Motor Safety Factor
Motor Manufacturer & Size
Voltage & Phase

PUMP DESIGN & DELIVERED CONDITIONS

Pump Rpm
Pump Inlet & Outlet Pressure
Amperage
Brake Horsepower
Gpm Supply

SYSTEM DESIGN & DELIVERED CONDITIONS

Flow (Gpm) through each pump
Inlet & Outlet temperature at 3-way valve
Flow (Gpm) through each coil
Inlet & Outlet Pressure at each coil
Inlet & Outlet temperature at each coil
Type of instrument and method used

3.5 INSTALLATION TOLERANCES:

- A. Adjust hydronic system to the following tolerances:
 - 1. Supply water temperature 0 deg F to 120 deg. F 0% to -5% to +5% of design value.

3.5 FIELD VERIFICATION:

- A. The design Engineer may request verification of data contained in the balancing report. If requested the TAB technician whose initials appear on the data sheets shall take outlet and inlet readings selected at random by the Engineer who will compare these readings to those in the submitted report. If the field verification is not satisfactory, the firm doing the TAB work shall completely rebalance the system and a new report shall be prepared and submitted for approval.

END OF SECTION 23 05 93

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 01, General requirements, apply to the work specified in this Section.
- B. The requirements in Section 23 05 00 shall also govern the work under this Section.
- C. Scope of Work: This Section contains details for the insulation of pipe, ductwork and equipment installed under Division 23.

1.2 SUBMITTALS:

- A. In accordance with Section 01 33 00, the following items shall be submitted for approval.

Chilled Water pipe insulation
Equipment insulation
- B. Recycled Content: Provide data showing recycled materials content of materials and fabricated items provided for this project, stated as a percentage of the materials included in these items or materials provided as part of the Work of this Section.
- E. Connecticut High Performance Building Submittals:
 - 1. Product Data: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
 - 2. Laboratory Test Reports: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.3 MECHANICAL SYSTEMS INSULATION:

- A. Furnish and install all thermal and protective insulation as specified herein for piping and equipment as shown on the drawings.
- B. The following mechanical items shall be insulated:
Fittings - Valve bodies, Victaulic couplings, elbows, tees, etc.
Equipment insulation

1.4 SYSTEM PERFORMANCE

- A. Insulation materials furnished and installed hereunder should meet the minimum thickness requirements of ASHRAE 90.1 (2013), "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air Conditioning Engineers. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor.

- B. Insulation materials furnished and installed hereunder shall comply with NFPA 255 and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with the following testing standard:

Underwriters' Laboratories, Inc. UL 723

Adhesives used for applying the sealed jackets shall also conform to these same ratings. The use of wheat paste or any other material not meeting these requirements will not be allowed.

1.5 **QUALITY ASSURANCE**

- A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.
- C. All covering and insulating materials shall be manufactured by Johns Manville, Knauf, Owens-Corning or Armstrong.

1.6 **DELIVERY AND STORAGE OF MATERIALS**

- A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.
- B. The contractor shall use whatever means are necessary to protect the insulation materials and accessories (wick material, sealing tape, etc) before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.

PART 2 - PRODUCTS

2.1 **PIPING:**

- A. Insulate all new chilled water and condensate lines with Owens-Corning Fiberglass ASJ with S.S.L. II, pipe insulation with double self-sealing lap having a factory applied jacket. Acceptable manufacturers are Johns Manville and CertainTeed. All horizontal and vertical insulated piping located below 8'-0" AFF level and not protected with enclosures shall be protected with Zeston 2000 P.V.C. 30 Mil jacketing. Acceptable equals are by Speed Line or Proto.
- B. All concealed piping shall be covered as follows: Apply insulation to clean dry pipe with side and end joints butted tightly. Seal lap of jacket and butt joint strips with Benjamin Foster 82-07 vapor barrier lap adhesive. Insulate fittings, flanges and valves of piping with mitered pipe insulation, or F/G premolded fittings made smooth with insulating cement and jacket with glass cloth saturated with Benjamin Foster 30-60 lagging adhesive. Vinyl or plastic fitting jackets will be allowed.
- C. For all the chilled water piping vapor seal all joints, seams, elbows and fittings.

- D. For all insulated pipes, including refrigerant piping, exposed to weather apply a 16 mil embossed aluminum jacket with 2" overlap at longitudinal and circumferential joints. Secure in place with 3/4" x .015" aluminum band 18" on centers. All seams shall be sealed weather tight.
- E. Foam insulation:
1. Piping and Fittings. MicroLok plain pipe insulation shall be wired or taped in place over clean, dry pipe with all joints butted firmly together. Vapor retarder shall be Micro-Lok AP-T plus.
 2. The insulation shall be finished with metal jacketing with a laminated moisture retarder. Metal jacketing shall be overlapped 2 to 3 inches (51 to 76 mm) and held in place with sheet metal screws or metal bands.
 3. Elbows and tees shall be finished with matching metal fitting covers. Other fittings in metal-jacketed systems shall be finished with conventional weather-resistant insulating materials with painted aluminum finish.
- F. Provide minimum insulation thickness in accordance with the following table.

Minimum Pipe Insulation

Piping System Types	Conductivity	Mean Rating temp	Fluid Temp. Range	Runout 2 in +	1 in. and less	1-1/4 to 1 1/2	2 to 4 in.	5 and Larger
					in.	in.	in.	in.
	BTUin/hsqftF	F	F	in.	in.	in.	in.	in.
Cooling Systems								
Chilled Water or Refrigerant	.22-.28	100	40-60	1.0	1.5	1.5	1.5	1.5
	.22-.28	100	Below 40	1.0	1.5	1.5	1.5	1.5

2.2 FITTING COVERS:

- A. Fitting covers may be used in lieu of insulating cement and jacket. Provide fitting covers in Zeston - 2000 P.V.C. (20 Mil thickness) by Manville. Provide color coded fitting covers in Zeston 300 Series 30 Mil jacket for fittings located in the Mechanical Room, Mechanical Mezzanine and Mechanical Penthouses. Acceptable alternate manufacturers are by Speed Line or Proto.
- B. General - The matching insert (fiberglass) should either be wrapped completely around the fitting or snugly positioned inside the fitting for proper fit. The insert shall cover the full inner surface area of the fitting cover. The fitting cover is then to be applied over the fitting and insert, and the throat secured by either tack fastening, taping, or banding.
- C. Cold Pipe - Fitting systems below ambient temperature must have a continuous vapor barrier, either with pressure sensitive PVC Tape, or an approved adhesive system. When PVC Tape is used, a 2" downward lap is required. On cold lines in severe ambient temperatures, the fiberglass insert shall be the same thickness as the adjacent pipe insulation. All joints shall then be sealed with PVC Tape.

PART 3 – EXECUTION

3.1 SITE INSPECTION

- A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.
- B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturer's recommendations.
- C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 PREPARATION

- A. Ensure that insulation is clean, dry, and in good mechanical condition and that all factory-applied facings are intact and undamaged. Wet, dirty, or damaged insulation is not acceptable for installation.
- B. Ensure that pressure testing of piping, duct and fittings has been completed prior to installing insulation.

3.3 INSTALLATION

- A. General
 - 1. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
 - 2. Install insulation on piping/duct subsequent to painting, and acceptance tests.
 - 3. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
- B. Fittings
 - 1. Wrap valves, fittings, and similar items in each piping system with wicking material to ensure a continuous path (100% coverage) for the removal of condensation.
 - 2. Seal all fitting joints with contractor supplied VaporWick Sealing Tape. Approved vapor retarder mastic compound may be utilized in lieu of the tape, subject to approval by the Engineer.

C. Penetrations

Extend piping and duct insulation without interruption through walls, floors and similar piping or duct penetrations.

3.4 SEAMS:

- A. On exposed insulation, all longitudinal seams shall be kept at the top and back of the pipe and circumferential joints shall be kept to a minimum. Raw end of insulation shall be concealed by neatly folding the ends of the jackets. Fittings, valve bodies and flanges shall be furnished with the same jacket materials used on adjoining insulation.

3.5 PRIOR TESTING:

- A. Covering shall not be applied until all parts of the work have been tested by the Contractor and reviewed by the Engineer.

3.6 VAPOR BARRIER:

- A. Vapor barrier shall be applied in accordance with the manufacturer's instructions to maintain the integrity of the vapor barrier on cold systems.
- B. An approved vapor retarder mastic compatible with PVC must be applied between pipe insulation and fitting cover, and on fitting cover and throat overlap seam.
- C. For fittings where operating temperature is below 45 deg. F or where pipe insulation thickness is greater than 1 1/2", two or more layers of Hi-Lo temp insulation inserts shall be installed beneath fitting cover.

3.7 METAL SHIELDS:

- A. Metal shields, 16 gauge galvanized, shall be applied between hangers or supports and the pipe insulation. Shields shall be roll formed to fit the insulation and shall extend up to the center line of the pipe and the length specified for the insert. Insulation shall be rigid type for length of shield to prevent crushing.

3.8 FIELD QUALITY ASSURANCE

- A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.
- B. Replace any ceiling damage caused by condensation due to improper covering and sealing during the guarantee period of this job.

3.9 PROTECTION

- A. Replace damaged, removed or disturbed insulation with appropriate fiberglass insulation.
- B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.10 SAFETY PRECAUTIONS

- A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.
- B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

END OF SECTION 23 07 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this Section.
- B. The requirements in Section 23 05 00 shall also govern the work under this Section.
- C. Examine all drawings and data and coordinate the work of this Section with all related and adjoining work.

1.2 SCOPE OF WORK:

- A. This Contract includes all labor, material, equipment, tests and appliances required to furnish and install all hydronic piping as shown by Drawings, as implied and herein specified.
- B. Visit the site and familiarize with the existing conditions; review all Drawings and Specifications of all other Sections affected by the Work of this Section and coordinate the Work of this Section accordingly.
- C. Connect all equipment with piping, ductwork and controls and leave ready to operate.
- D. Provide seismic restraints, vibration isolators and flexible connections in accordance with Section 23 05 48. Provide flexible connections at all locations where pipes cross building seismic or expansion joints. Coordinate with all other Sections affected by the work of this Section.
- E. Drawings are diagrammatic and indicate the general arrangement of piping and do not show all minor details and fittings. Such items shall be included, as well as reasonable modification, in the layout as directed to prevent conflict with other trades.

1.3 SUBMITTALS:

- A. The following items shall be submitted for review.
 - Pumps
 - Pipe and fittings
- B. Recycled Content: Provide data showing recycled materials content of materials and fabricated items provided for this project, stated as a percentage of the materials included in these items or materials provided as part of the Work of this Section.
- C. Connecticut High Performance Building Submittals:
 - 1. Product Data : For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports : For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services')

"Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- B. Delegated-Design Submittal:
1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
 2. Locations of pipe anchors and alignment guides and expansion joints and loops.
 3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
 4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 ACCESS DOORS AND PANELS:

- A. Furnish and set access doors and frame for all valves and controls which are concealed in furred spaces. Furnish access doors according to requirements of Section 08 31 16 "Access Panels and Frames". Provide stainless steel in all wet areas. Access doors shall be fire rated consistent with wall or ceiling in which they are installed.
- C. Where access is required to valves, etc., that occur above lay-in ceilings, these access doors can be omitted, provided suitable plastic markers identifying exact location of valves etc., on lay-in ceilings are applied directly below valve grouping and identified by a number, this number to be used as a marking on valve chart. Markers shall be applied to the ceiling grid, not the ceiling tile.

1.5 QUALITY ASSURANCE:

- A. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 -PRODUCTS

CENTRAL CONNECTICUT STATE UNIVERSITY (CCSU)
ENERGY CENTER- CHILLER ADDITION
DCS PROJECT NO: BI-RC-408

2.1 PIPE AND FITTINGS:

A. Copper Tubing:

1. Type "L", ASTM Specifications B88, shall be used for water lines.
2. Fittings shall be wrought copper or cast brass solder- joint pressure rated type.
3. Type "K" shall be used for underground piping with flared fittings.

B. Steel Piping:

1. Pipe shall be Standard Wall (Sch. 40) black carbon steel, ASTM A-120, Grade B, with threaded ends for sizes 1/2" through 2", for hot water heating piping.
2. Fittings shall be standard weight (125 lbs.), cast iron screwed, ASTM A126, Class A, for sizes 1/2" through 2". Piping 2" and under shall be screwed.
4. Victaulic Grade E couplings, fittings and accessories in conjunction with grooved end schedule 40 piping will be permitted in existing and new construction for hot water heating system.

2.2 PIPE AND FITTINGS:

- A. All fittings on welded lines shall be furnished in accordance with ASTM A105 Specification designed for welding. Branch outlets on mains 2-1/2" and smaller to be made with Weldolets or Thredolets. Welding fittings on mains and branches 3" and larger are to be full size of reducing tube designed for welding. All flanged valves 3" and larger and special equipment connections to be installed with weld neck flanges for welded construction.
- B. All nipples shall be extra strong as follows: Pipe size 1/2" to 4" - 6" close. Pipe size 5" - 12" - 12" close and of the same material as the piping they are used with.
- C. All copper tubing shall be furnished in Type "L" using sweat fittings unless otherwise noted. Copper tubing shall be furnished by Chase, Anaconda, Bridgeport or Revere.
- D. All black steel over 4" or other welded pipe shall have long radius welding ells and tees of the same wall thickness as the pipe. Welding tees will not be required where the mains and branches comply with the following schedule:

<u>Min. Size of Mains</u>	<u>Max. Size of Branch</u>
2 1/2"	3/4"
3"	1 1/4"
4"	2"
5"	3"

- E. Welding flanges shall be slip-on or welding neck type, 300 psig forged steel conforming to ANSI Specification B-16.5.
- F. All necessary precautions shall be taken when welding in the new building to prevent combustion of structure.

2.3 GROOVE PIPING:

- A. Victaulic couplings may be used in lieu of welding, thread or flanging on 2 1/2" through 30" carbon steel pipe, on heating water services from -30 deg. F. to 230 deg. F. within the manufacturer's rated working pressures. Pipe grooving shall be cut grooved and/or rolled grooved as per manufacturer's latest spec. Installation is per manufacturer's latest recommendations. All piping shall be Schedule 40. grooved piping shall be used only in concealed or service areas. Grooved piping will not be accepted in finished areas with no ceiling.

B. Piping Components

Grooved couplings consisting of two or more pieces of ductile or malleable iron. Coupling gaskets will be a synthetic rubber gasket with a central cavity pressure responsive design. Coupling bolts and nuts shall be heat treated carbon steel, track head conforming to physical properties of ASTM-A-183. All grooved couplings shall be as manufactured by Victaulic Co. Style 77, 07 or equal in Grinell or Viking Johnson.

- C. For piping 2 1/2" and larger, full size branch connections shall be made with manufactured grooved end tees. Branch connections for less than full size shall be made with Victaulic hole cut products or equal in Grinell or Viking Johnson. Style 920 or Style 921 branch connections with locating collar engaging into hole or style 72 outlet coupling used to join grooved pipe and to create a branch connection.

Gaskets for branch connection shall be Victaulic Grade "E" EPDM Compound with working temperature of -30 deg. F. to 230 deg. F.

D. Flanges

Vic-Flange Style 741 (2-24") for connection to ANSI class 125 and 150 flanged components.

E. Fittings

Fittings shall be full flow cast fittings, steel fittings or segmentally welded fittings with grooves or shoulders designed to accept Victaulic grooved end couplings.

1. Standard Fittings - shall be cast of ductile iron conforming to ASTM A-536 (Grade 65-45-12) or malleable iron conforming to ASTM A-47, Grade 32510, painted with a rust inhibiting modified vinyl Alkyd enamel or hot-dip galvanized to ASTM A-153 or zinc electroplated to ASTM B-633, as required.
2. Standard Steel Elbow Fittings - (14" - 24"), shall be forged steel conforming to ASTM A-106 Grade B (0.375" wall), painted with rust inhibiting modified vinyl Alkyd enamel or hot-dip galvanized to ASTM A-153.
3. Standard Segmentally Welded Fittings - shall be factory fabricated, by fitting manufacturer, of carbon steel pipe as follows, 3/4" - 4" conforming to ASTM A-53, Type F; 5" - 6" Sch. 40 conforming to ASTM A-53, Type E or S, Grade B; 8" - 12" Sch. 30 conforming to ASTM A-53, Type E or S, Grade B; 14" - 24" 0.375" wall conforming to ASTM A-53, Type E or S, Grade B, painted with rust inhibiting modified vinyl Alkyd enamel or hot-dip galvanized to ASTM A-153, as required.

F. Victaulic Pipe Hanging (Victaulic Hanging Standard A-130)

1. Style 07 Zero-Flex for rigid piping systems should be supported as per Building Services B31.9 Hanging.

2. Style 77 flexible piping systems are supported as per Victaulic Hanging Standard A-130.

2.4 PIPING JOINTS:

- A. Welded Joints shall be fusion welded in accordance with American Standard B31.1, Section 6, except as modified hereinafter. Changes in direction of piping shall be made with welding fittings only. Mitering, notching or direct welding of pipe to the main in order to form tees or ells will not be permitted. Branch connections may be made with welding tees or forced branch outlet fittings, as manufactured by Bonney Forge, either being acceptable without size limitation. Bonney Thredolets shall be used in lieu of Hald couplings when reducing from a welded run to a screwed branch. Outlet fittings where used shall be forged, flared for improved flow where attached to the run, reinforced against external strains and designed to maintain full pipe bursting strength. Fillet welds shall be used for welding screwed and slip-on steel flanges to pipes. Where lateral connections are to be used, either lateral fittings or Bonney Latrolets are acceptable. Welded joints shall be used in finished areas with no ceiling.
- B. Screwed Joints: The ends of pipes to be threaded shall be cut square and reamed. Pipe threads shall be standard taper, shall be cut straight and clean and to full depth, and shall be free from dirt, chips and burrs when the joint is made. Pipe joint lubricant or compound shall be selected for the pipe line service and shall be applied to male threads only. Screwed joints shall not be caulked.
- C. Flanged Joints: This heading covers flanged joints of all types, including those made with flange unions. Flanged joints shall be made with suitable reinforced gaskets. Clean all parts and align the joint before assembling; support pipes or heavy parts independently. Opposite bolts shall be pulled up successively. Screwed steel flanges shall be welded to pipes; slip-on steel flanges shall be welded front and back.

Cast iron flanges shall not be welded to pipes. If raised face flanges are to be bolted against plain face flanges, the raised face shall be removed and a full face gasket used. Where flanged base elbows are installed, the base shall not be used for anchoring the line or otherwise subjected to tension or shear.

- D. Soldered Joints in Copper Tubing: Cut the ends of tubes square, remove burrs, clean tube ends and fitting sockets with emery cloth and remove all particles before applying flux and making the joint. Insert tubes to full socket depth. Use the following solders at the given conditions.

95 - 5% Tin-Antimony/all services/high pressure 250 degrees F. Max.
Silver - 35 to 45% alloy-refrigerant piping/high pressure and temperature.

2.5 PIPE HANGERS:

- A. Securely hang and anchor pipe as shown and required with proper provision for expansion, contraction and elimination of undue stress and strain on piping.
- B. Provide a pipe hanger within two (2) feet of each elbow, tee, wye, valve, strainer and similar device.
- C. Secure and support runs at base and at sufficiently close intervals to hold pipe at alignment and to carry safely the weight of piping and contents without undue stress thereon.

- D. Except as indicated to the contrary, secure and support all horizontal piping as follows and required to prevent sagging, undue pipe movement and preserve proper alignment in each run.

<u>Piping</u>	<u>Sizes</u>	<u>Maximum Interval</u>
Cast Iron	All sizes	At each hub or joint
Steel	2" & smaller	Six (6) feet
Steel	2 1/2" & larger	Ten (10) feet
Copper Tubing	1 1/4" & smaller	Five (5) feet
Copper Tubing	1 1/2" & larger	Eight (8) feet

- E. Hangers up to and including 2" shall be the adjustable band type equal to Empire. Figure 310 for iron pipe and Fig. 310CT for copper tubing.
- F. Hangers for piping 2-1/2" and up shall be the clevis type, equal to Empire. Figure 11 for iron pipe and Figure 110CT for copper tubing.
- G. Hangers shall be suspended from one of the following devices:
1. "C" clamps.
 2. Trapeze hanger assemblies consisting of back-to-back horizontal steel channels with end-type rod hangers.
 3. Expansion shield embedded into concrete or masonry.
 4. Anchor hangers to steel structural members, concrete or masonry. Do not anchor to metal floor deck, steel deck tabs or metal roof deck.
- H. On hot and chilled water systems, provide over-sized hangers.
- I. Refer to Section 23 05 48 for Seismic Restraints.

2.6 VALVES:

- A. This Contractor shall furnish and install valves where shown on plans and also wherever necessary to make the system complete in its operation. All valves shall be as manufactured by Stockham, Jamesbury, Centerline, Appollo, Milwaukee or Victaulic.

Chilled Water:

2" and smaller

Ball valves	Apollo 71-100/200
Check valves	Stockham B-310-T
Vertical check valves	Stockham B-310-T

2-1/2" and larger

Butterfly valves	Stockham - LG712-BS3-B (Lug Style)
Check valves	Centerline - Series 800 S.S. plate and spring, and nypalon seats.

Furnish all valve materials suitable for service intended. No gate valves shall be allowed. Provide all valves with factory installed extension stems.

2.7 UNIONS:

- A. All unions shall be furnished in Nibco-633 or equal by Chase, Revere, Jefferson or Anaconda.

2.8 GASKETS:

- A. Where flanges occur, they shall be packed with Klinger or approved equivalent high quality non-asbestos material composed of fibers for industrial maintenance service with high chemical stability and heat resistance. Nitrile rubber bonded.

Temperature	750 deg. F. max.
Pressure	1450 psi max.
Compressibility	ASTM F36A
Tensile Strength	ASTM F152

2.9 FLOOR AND CEILING PLATES:

- A. Furnish and install satin chrome plated pressed metal floor and ceiling plates on all exposed pipes passing through floors, walls, ceilings, and partitions throughout.

2.10 REAMING OF PIPES:

- A. All pipes to be carefully reamed after cutting and threading.

2.11 PIPE ANCHORS:

- A. Furnish and install all steel clamps around mains not less than 1/4" thick and welded to pipe and necessary angle braces to substantial construction to meet job conditions. Anchored mains shall be properly guided.
- B. Vertical risers, if any, shall be anchored by similar clamps secured to floor, concealed in wall construction.

2.12 EXPANSION LOOPS AND JOINTS:

- A. Furnish and install all expansion joints with mains and loops properly anchored and guided to allow for the necessary expansion of mains and all run outs shall be piped to allow for necessary expansion on risers and mains. In cases where space is limited, expansion joints with compensators, guides and anchors may be used in place of expansion loops as approved by the Engineer.
- B. Provide all expansion joints in Keflex or equal in Fulton Syphon, Flexonics or Adsco, with compensator guides and anchors. Piping joints 3" and larger shall be free- flexing type with Type 304 stainless steel bellows and 150-lb. van stone flanges. Lines of 2-1/2" and smaller shall be equipped with Quadra Side H compensators having multi-ply stainless steel bellows, carbon steel thread and shroud, each for 1" compression and 3" extension.
- C. Pipe alignment guides shall be installed in accordance with manufacturer's published bulletin. Anchors shall have sufficient strength to prevent movement of the piping beyond anchor points.

2.13 HANGERS AND SLEEVES:

- A. All horizontal piping shall be supported in a good, firm and substantial manner. No chains, horizontal pieces of pipe or hangers formed by means of perforated steel bands, pipe rings and hooks will be permitted. Provide cast iron ceiling plates for all hangers in finished basement ceilings. All hangers shall be oversized
- B. Furnish and place "Hole-Outs" plastic preformed knockout sleeves for all pipes passing through concrete or tile floors or partitions. All pipes passing through toilet room and mechanical room floors shall be provided with grouted, split Schedule 80 steel pipe sleeves, packed with hair felt and Portland cement to allow for flushing of floors without leakage. All pipes and conduits passing through floors, walls or partitions shall be provided with sleeves sized to give a minimum of 1/2" clearance between sleeve and the outside diameter of the pipe, conduit or insulation, enclosing the pipe or conduit.
- C. Sleeves through concrete floors or interior masonry walls shall be Schedule 40 steel pipe, set flush with finished wall or ceiling surfaces, but extending 2 inches above finished floors or shall be in accordance with details on drawings. In all mechanical equipment rooms or penthouses, sleeves shall extend 6 inches above finished floor.
- D. All outside piping passing through exterior walls, foundation walls and floors shall be furnished with flanged C.I. wall sleeves in Zurn, J.R. Smith or Josam. Furnish with flashing clamp where sleeve passes through waterproof membrane.

2.14 SPECIALTIES FOR CHILLED WATER SYSTEM:

- A. Furnish and install all chilled water equipment in Bell & Gossett as specified below and as shown on the drawings.
 - 1. Pressure reducing valve for each closed system.
 - 2. B & G Triple Duty flow control valves shall be furnished in either the angle type or straightaway to suit each individual location and full size of each main or branch main.
 - 3. Furnish all pumps as called for in schedule and following paragraph.
 - 4. Provide B&G circuit setter plus calibrated balancing valves Model C.B. on all radiation and air handling equipment.
- B. Furnish and install the following accessories and equipment as specified.
 - 1. Thermometers: Install Ashcroft Fig. 7173T BI-Metal "Every Angle" thermometers where shown and/or called for on plans or in specifications.
 - 2. Thermometers shall have 5" aluminum hermeticism sealed case with stainless steel stem with 1/2" NPT connection. Install in separable well in brass with lagging extension neck. Stem length and dial range shall be 6" and 0 degrees to 250 degrees F., respectively.
 - 3. Furnish and install on non-critical systems, gauges suitable for use on hot water where indicated on drawings or called for in specifications. Gauge shall be Ashcroft Fig. 2070 with silver brazed boudon tube, aluminum back flange type epoxy coated case, chrome ring, 1/4" NPT lower connection, stainless steel movement with 1% accuracy. Pressure range shall be as required. Furnish 1/4" needlepoint valve in Crane #88 for each gauge. Where sharp pressure fluctuations may occur, mount gauge on a 1/4" Fig. 1106B pulsation dampener. Provide compound gauges where required or called for.
 - 4. Furnish and install gauges on all pump discharge and compound gauges on all pump suction.

5. Furnish and install balancing valves on supply and return mains and branch mains from 1-1/2" and larger.
6. Expansion fittings shall be provided in Flexonics Type H expansion joints, sized as required to take up all expansion in mains and/or branches or equal in Anaconda.
7. Furnish and install all balancing valves on radiation, air handling unit coil, fan coil unit coil, cabinet and unit heater coil, etc., runouts 2" and smaller in Tour Andersson STA-D Series with "A metal" construction. Branch mains 2 1/2" and larger shall be provided with Tour Andersson STA-F Series balancing valve.
8. Furnish and install dielectric fittings.
9. Furnish and install brass cap with chain on all strainers, drains and hose connections.

2.15 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
Description:

Standard: ASSE 1079.
Pressure Rating: 150 psig minimum at 180 deg F
End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
Description:

Standard: ASSE 1079.
Factory-fabricated, bolted, companion-flange assembly.
Pressure Rating: 150 psig minimum at 180 deg F
End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
Description:

Nonconducting materials for field assembly of companion flanges.
Pressure Rating: 150 psig.
Gasket: Neoprene or phenolic.
Bolt Sleeves: Phenolic or polyethylene.
Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples:
Description:

Standard: IAPMO PS 66.
Electroplated steel nipple, complying with ASTM F 1545.
Pressure Rating: 300 psig at 225 deg F.
End Connections: Male threaded or grooved.
Lining: Inert and noncorrosive, propylene.

2.17 DOUBLE SECTION HORIZONTAL SPLIT CASE:

A. Manufacturer:

1. Contractor shall furnish and install new double suction horizontal split case pumps for chilled water and hot water heating systems as indicated on the drawings. Pumps shall be as manufactured by **Bell & Gossett** under base bid. Equivalent units as manufactured by others may be submitted as deduct alternates. Pumps shall meet types, sizes, capacities, and characteristics as scheduled on the Equipment Schedule drawings.

B. Double Suction, Horizontal Split Case Pump (Base Mounted):

1. The pumps shall be long coupled, base mounted, single stage, double suction, horizontally split case design, in cast iron stainless fitted construction specifically designed for quiet operation. Suitable standard operations at 250°F / 120°C (and 175 PSIG /16bar working pressure or optional operations at up to 300°F / 150°C and 400 or 450 PSIG / 25 bar or 31 bar working pressures. Working pressures shall not be de-rated at temperatures up to 250°F / 120°C. The pump internals shall be capable of being serviced without disturbing piping connections or electrical motor connections, and the pump's internal seals and bearings shall be serviceable without disturbing the upper casing half when maximum working pressure is less than or equal to 175PSIG/16bar.
2. A bearing housing shall supply support for a pair of heavy-duty regreaseable ball bearings. An inboard single row bearing shall absorb thermal expansive forces while an outboard single row bearing shall be clamped in place to absorb both radial and thrust loads and keep the rotating element in proper axial alignment. Bearings shall be replaceable without disturbing the system piping, the upper casing half, and shall be regreaseable without removal of the bearings from the bearing housing. Ratio of length to diameter of the shaft design shall be no greater than 14 to minimize shaft deflection and maximize bearing and seal lives.
3. The pump shaft shall be a solid heat treated 420 stainless steel shaft.
4. Pump shall be equipped with a pair of internally self flushing mechanical seal assemblies in direct contact with the pump shaft. Seal assemblies shall be unbalanced elastomeric seals having a stainless steel spring, and be of a carbon face rotating against a stationary silicon carbide face with an EPDM elastomeric bellow. Mechanical seals shall be replaceable without disturbing the upper casing half and system piping when suction pressure less than or equal to 175PSI [12 bar].
5. Impeller shall be of the enclosed double suction type made of 304 SS, both hydraulically and dynamically balanced to grade G6.3, keyed to the shaft and fixed in the axial position by retaining ring.
6. A flexible spacer type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. On variable speed applications the coupler sleeve shall not be constructed of a nylon material to maximize performance life.
7. An OSHA and ANSI rated coupling guard shall shield the coupling during operation. Coupler guard shall be dual rated ANSI B11.19, OSHA 1910.219 and CE compliant coupling guard and contain viewing windows for inspection of the coupling. No more than 0.25 inches

[6 mm] of either rotating assembly shall be visible beyond the coupling guard. Coupling guard shall have an adjustable mount to the baseplate. Coupling guard shall be provided with viewing slots for visibility of rotating coupling components during pump operation.

8. Pump volute shall be of a class 35 cast iron (rated for 175 PSIG / 16 bar maximum working pressure) or class 65-45-12 ductile iron (rated for 400 or 450 PSIG / 25 bar or 31 bar maximum working pressure) axially-split design with flanges (175 PSIG / 16bar casing drilled with 125# ANSI / PN 16 companion flanges or optional 400 and 450 PSIG / 25 bar and 31 bar casing working pressures are drilled with 250# ANSI / PN25 or PN40 flanges) and mounting feet integral cast into the bottom half of the casing. Suction and discharge flanges shall be on a common centerline in both the horizontal and vertical planes, and the volute shall include: priming port, gauge ports on bosses near nozzles, and vent and drain ports. The upper half casing shall be capable of being removed without disturbing piping connections or electrical motor connections. Bearings housings should include ports for measurement of temperature and vibration (in two axes). Bearing temperature measurement shall be measured at outer raceway of the bearing.
9. The pump seal flushing shall be internal within the pump casing.
10. Motors shall meet scheduled horsepower/kW, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve within POR and shall meet NEMA/IEC specifications and conform to the standards outlined in EPACK 92.
11. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8-2013 for *Horizontal Baseplate Design* standards. Base plate shall be fitted with dog-point jacking screws for optimal motor alignment.
12. Pump rotation shall be right-hand or left-hand with respect to the discharge flange as viewed from the pump's outboard/non-drive end.
13. The pump(s) selected shall conform to ANSI/HI 9.6.3.1-2017 standards for Preferred Operating Region (POR) unless otherwise approved by the engineer. The pump NPSH shall conform to the ANSI/HI 9.6.1-2017 standards for *Rotodynamic Pumps - Guideline for NPSH Margin*.
14. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2016 standard for *Rotodynamic Pumps for Vibration Measurements and Allowable Values*, for recommended acceptable unfiltered field vibration limits for pumps with rolling contact bearings.
15. Pump manufacturer shall be ISO-9001 certified.
16. Each pump shall be factory hydrostatically tested to 1.5 times maximum working pressure for 10 minutes per Hydraulic Institute standards and name-plated before shipment. It shall then be thoroughly cleaned and painted with at least one coat of high grade paint prior to shipment.

- C. Accessories:
 - A. Where noted on schedule pumps shall be provided with internal bronze casing wear rings, special shaft materials, special impeller materials or impeller wear rings, or non-spacer couplings.
 - B. Where noted on schedule either unbalanced seals of Silicon carbide/silicon carbide/EPDM, Carbon/silicon carbide/FKM, Silicon carbide/silicon carbide/FKM
 - C. Where noted on schedule pumping equipment may require one or all of the following tests: Certified Lab tests (unwitnessed or witnessed), NPSHR, or temperature testing.
 - D. Where noted on schedule pumping equipment may require non-grouted, drip pan, solid top, or drip rim base plates.
 - E. Where noted on schedule pump may require special coating (internal or external).
 - F. Where noted on schedule impeller or rotating element may require balancing to G2.5 (impeller) or G1.0 (rotating element).

PART 3 -EXECUTION

3.1 INSTALLATION:

- A. Furnish and install all the chilled water piping as indicated on plans. Furnish and install all control valves, flow valves, air vents, gate valves and/or balancing valves and drain valves.
- B. Check all electrical drawings to make sure that this piping will not conflict with such work.
- C. All piping work shall be installed with proper provision to allow for expansion and contraction of lines so as to prevent any undue strains on pipe and fittings, any trapping of lines or lifting or dislocating of any appliances. Rectify without cost to the Agency any conditions of noisy circulation due to trapped or air bound lines, including the expense of cutting and repairing of the building structure incident to making such alterations.
- D. Install the work to conform to space conditions and the work of other trades. The drawings indicate generally the runs and sizes of piping and, although the size must not be decreased, nor the drawings deviated from, except as unforeseen space conditions may require, the right is reversed to make minor changes in the arrangement of the work to meet conditions arising during construction.

3.2 MISCELLANEOUS PIPING:

- A. Furnish and install refrigerant relief vent pipes.

3.3 TESTING:

- A. All flow piping shall be tested and made tight.
- B. All piping shall be tested and made tight at 100 psi or 50 psi above the city pressure before any piping is concealed or approved.
- C. After the system is thoroughly cleaned, it shall be put into operation by this Contractor. All parts of the system shall be thoroughly tested and this Contractor shall carefully instruct the Agency's authorized representative as to the proper operation and are of the entire system.

- D. All low pressure piping shall be tested and made tight at 100 lbs. per square inch hydrostatic pressure before any piping is concealed or covered.
- E. Contractor shall purge all returns for a minimum period of two weeks after all supply lines, return lines and heating surfaces have been connected up and in operation or until all traces of grease, oil and dirt disappear.
- F. After the systems are thoroughly cleaned, they shall be put into operation by the Heating Contractor after all traps and strainers have been removed and cleaned. All parts of the system shall be thoroughly tested and this Contractor shall carefully instruct the Agency's authorized representatives as to the proper operation and care of the entire system.

3.4 FLUSHING OUT SYSTEM:

- A. Contractor shall flush out the chilled water systems before balancing up the systems.

3.5 BALANCING AND VENTING OF CHILLED WATER SYSTEM:

- A. Contractor shall provide all labor and materials as required to assist the Balancing Contractor in proper balancing of the water systems. Contractor shall return to the job and shall make necessary adjustments and corrections to the systems as required by the Balancing Contractor in order to achieve satisfactory system performance in accordance with design parameters.
- B. Contractor shall carefully vent the system when filling same and return to the job during the eighteen months guarantee period as required, to assure the Agency of a proper operating system.
- C. System shall be slowly filled with cold water to purge air and shall maintain 4 psig on a gauge located conveniently near the top of the system.

END OF SECTION 23 21 13

PART 1 GENERAL

1.01 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and Division 1, General Requirements, apply to the work specified in this Section.
- B. The requirements in Section 23 05 00 shall also govern the work under this Section.
- C. Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled centrifugal chiller.
- D. Examine all drawings and data and coordinate the work of this Section with all related and adjoining work.

1.02 SCOPE

- A. Section includes design, performance criteria, controls and control connections, chilled water connections, electrical power connections and refrigerants of the chiller package.

1.03 REFERENCES

- A. Products shall be designed, rated and certified in accordance with applicable sections of the following Standards and Codes:
 - 1.To comply with the most recent versions of applicable Standards and Codes of ARI 550 / 590.
 - 2.NEC
 - 3.To comply with the most recent versions of applicable Standards and Codes of ANSI/ASHRAE 15.
 - 4. Units shall meet the efficiency standards of the latest ASHRAE 90.1 Standard.
 - 5. Unit shall comply with ASME section VIII
 - 6. OSHA as adopted by the State.

1.04 QUALITY ASSURANCE

- A. UL 1995 -- Standard for Heating and Cooling Equipment.
- B. Manufactured facility to be ISO 9001.
- C. Factory Functional Test: The chiller shall be pressure tested, evacuated and fully charged with

HFC-410A refrigerant and oil. In addition, a factory functional test to verify correct operation by cycling condenser fans, closing compressor contacts and reading data points from temperature and pressure sensors.

- D. Qualifications: Equipment manufacturer must specialize in the manufacture of the products specified and have five years of experience with the equipment and refrigerant offered.
- E. Regulatory Requirements: Comply with the codes and standards specified.

1.05 SUBMITTALS

- A. Submit shop drawings and product data in accordance with specification requirements.
- B. Submittals shall include the following:
 - 1. Dimensioned plan and elevation view drawings, required clearances, and location of all field connections.
 - 2. Summary of all auxiliary utility requirements such as electricity, water, etc. Summary shall indicate quality and quantity of each required utility.
 - 3. Diagram of control system indicating points for field interface and field connection. Diagram shall fully depict field and factory wiring.
 - 4. Manufacturer's certified performance data at full load plus IPLV or NPLV.
 - 5. Installation and Operating Manuals

1.06 OPERATION AND MAINTENANCE DATA

- A. Include manufacturer's descriptive literature, installation checklist, start-up instructions and maintenance procedure.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Chillers shall be delivered to the job site completely assembled and charged with refrigerant and oil by the manufacturer.
- B. Comply with the manufacturer's instructions for rigging and handling.
- C. If unit is to be stored, comply with manufacturer instructions for storage.
- D. During shipment, provide protective covering over vulnerable components. Fit nozzles and open pipe ends with enclosures.

1.08 WARRANTY

- A. The refrigeration equipment manufacturer's warranty shall be for a period of five years from date of substantial completion. The warranty shall include parts and labor costs for the repair or replacement of defects in material or workmanship. The refrigerant warranty shall match the parts and labor warranty.

1.09 SUSTAINED OPERATIONAL PERFORMANCE AND RELIABILITY

- A. During the first 24 months of operation, the manufacturer shall perform quarterly remote or on-site operating inspections to confirm the chiller's operational performance. Resulting from each inspection, the manufacturer shall provide the Agency with a report describing the condition of the equipment and each of its major components, a log of its current operating data, any issues needing to be addressed, and any recommended corrective actions.
- B. Manufacturer shall include chiller spring start-up and fall draining and winterizing services for the first 24 months of operation.

1.10 SUMMARY OF GENERAL OPTIONS

- A. Warranty: List design requirement options listed in section 1.06.
- B. Sustained Operational Performance: List design requirement options listed in section 1.09.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Basis of Design - Daikin Applied Chiller Model WDC, including the standard product features and all special features required per the plans and specifications.
- B. Equal Products - Equipment manufactured by York and SMARTD may be acceptable as an equal. Naming these products as equal does not imply that their standard construction or configuration is acceptable or meets the specifications. Equipment proposed "as equal", must meet the specifications including all, mechanical, electrical, and structural details, all scheduled performance and the job design, plans and specifications. Any required modification (design and installation) to the specified design required to accommodate other than the specified unit are the Contractor's responsibility.

2.02 UNIT DESCRIPTION

- A. Provide and install as shown on the plans a factory-assembled, factory charged, water-cooled packaged chiller. Each unit shall be complete with a single-stage hermetic centrifugal compressor with lubrication and control system, factory mounted starter, evaporator, condenser, refrigerant control device and any other components necessary for a complete and operable chiller package. Chiller shall be factory run-tested on an AHRI certified test stand with water at job conditions (excluding glycol applications). Operating controls shall be adjusted and checked. The refrigerant charge shall be adjusted for optimum operation and recorded on the unit nameplate. Units operating with 50-Hz power shall be tested with a 50-Hz power supply. Any deviation in performance or operation shall be remedied prior to shipment and the unit retested if necessary to confirm repairs or adjustments.

2.03 DESIGN REQUIREMENTS

- A. General:
 - 1. Provide a complete water-cooled dual hermetic compressor centrifugal water chiller as specified herein. Machine shall be provided according to standards, Section 1.2. In general, unit shall consist of two compressors, refrigerant condenser and evaporator, two lubrication systems, two starters and two control systems. Note: Chillers shall be charged with a refrigerant such as HFC-134a, not subject to the Montreal Protocol and the U. S. Clean Air Act.
- B. Performance:
 - 1. Refer to the schedule of performance on the drawings. Performance shall be in accordance with applicable AHRI Standards.

C. Acoustics:

Octave Band									
	63	125	250	500	1000	2000	4000	8000	dBA
	—	—	—	—	—	—	—	—	

- 1. Sound pressure levels for the unit shall not exceed the following specified levels. The manufacturer shall provide the necessary sound treatment to meet these levels if required. Sound data shall be provided with the quotation. Test shall be in accordance with AHRI Standard 575.

2.04 CHILLER COMPONENTS

A. Compressors:

1. Unit shall have two single-stage hermetic centrifugal compressors. Casing design shall ensure major wearing parts, main bearings and thrust bearings are accessible for maintenance and replacement. Lubrication system shall protect machine during coast down resulting from a loss of power.
2. The impeller shall be statically and dynamically balanced. The compressor shall be vibration tested and not exceed 0.14 IPS.
3. Movable inlet guide vanes actuated by an internal oil pressure driven piston shall accomplish unloading. Compressors using an unloading system that requires penetrations of the compressor housing or linkages, or both, that must be lubricated and adjusted are acceptable provided the manufacturer provides a five-year inspection agreement consisting of semi-annual inspection, lubrication, and annual changeout of compressor seals. A statement of inclusion must accompany any quotations.
4. If compressors are not equipped with guide vanes for each stage and movable discharge diffusers, then furnish hot gas bypass and select chillers at 5% lower kW/ton than specified to compensate for bypass inefficiency at low loads.
5. For open motor units, an oil reservoir shall collect any oil and refrigerant that leaks past the seal. A float device shall be provided to open when the reservoir is full, directing the refrigerant/oil mixture back into the compressor housing. Manufacturer shall warrant the shaft seal, reservoir, and float valve system against leakage of oil and refrigerant to the outside of the refrigerating unit for a period of 5 years from the initial start-up including parts and labor to replace a defective seal and any refrigerant required to trim the charge original specifications.

B. Lubrication System:

1. Each compressor shall have an independent lubrication system to provide lubrication to all parts requiring oil. Provide a heater in the oil sump to maintain oil at sufficient temperature to minimize affinity of refrigerant, and a thermostatically controlled water-cooled oil cooler. Coolers located inside the evaporator or condenser are not acceptable due to inaccessibility. A positive displacement submerged oil pump shall be powered through the unit control transformer.

C. Refrigerant Evaporator and Condenser:

1. The evaporator and condenser shall be single circuit and be of the shell-and-tube type, designed, constructed, tested and stamped according to the requirements of the ASME

Code, Section VIII. Regardless of the operating pressure, the refrigerant side of each vessel will bear the ASME stamp indicating compliance with the code and indicating a test pressure of 1.1 times the working pressure but not less than 100 psig. Provide intermediate tube supports at a maximum of 18 inch spacing.

2. Tubes shall be enhanced for maximum heat transfer, rolled into steel tube sheets and sealed with Loctite or equal sealer. The tubes shall be individually replaceable and secured to the intermediate supports without rolling.
3. Provide sufficient isolation valves and condenser volume to hold full refrigerant charge in the condenser during servicing or provide a separate pumpout system and storage tank sufficient to hold the charge of the largest unit being furnished.
4. The water sides shall be designed for a minimum of 150 psig or as specified elsewhere. Vents and drains shall be provided.
5. Chilled water minimum refrigerant temperature shall be 33°F.
6. An electronic or thermal refrigerant expansion valve shall control refrigerant flow to the evaporator. Fixed orifice devices or float controls with hot gas bypass are not acceptable because of inefficient control at low load conditions. The liquid line shall have a moisture indicating sight glass.
7. The evaporator and condenser shall be separate shells. A single shell containing both vessel functions is not acceptable because of the possibility of internal leaks.
8. Reseating type spring loaded pressure relief valves according to ASHRAE-15 safety code shall be furnished. The evaporator shall be provided with single or multiple valves. The condenser shall be provided with dual relief valves equipped with a transfer valve so one valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the vessel. Rupture disks are not acceptable.
9. The evaporator, suction line, and any other component or part of a component subject to condensing moisture shall be insulated with UL recognized 3/4 inch closed cell insulation. All joints and seams shall be carefully sealed to form a vapor barrier.
10. Provide factory-mounted thermal dispersion flow switches on each vessel to prevent unit operation with no flow.

D. Prime Mover:

1. Squirrel cage induction motor of the hermetic type of sufficient size to efficiently fulfill compressor horsepower requirements. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase. Motor shall be compatible with the starting method specified hereinafter. If the Contractor chooses to provided an open drive motor or compressor, verify in the submittal that the scheduled chiller room ventilation system will accommodate the additional heat and maintain the equipment room at design indoor temperature based on 95°(F) outdoor ambient ventilation air available. If additional cooling is required, manufacturer shall be

responsible for the installation, wiring and controls of a cooling system. Chiller selection shall compensate for tonnage and efficiency loss to make certain the owner is not penalized.

E. Motor Starters:

1. The main motor starters are to be factory mounted and fully wired to the chiller components and factory tested during the run test of the unit. -- OR -- The main motor starters are to be furnished by the chiller manufacturer and shipped loose for floor mounting and field wiring to the chiller package. They shall be free-standing with NEMA-1 enclosure designed for top entry and bottom exit and with front access.
2. For open drive air-cooled motors the chiller manufacturer shall be responsible for providing the cooling of the refrigeration machinery room. The sensible cooling load shall be based on the total heat rejection to the atmosphere from the refrigeration units.
3. The starters must comply with the codes and standards in Section 1.2.

F. Chiller Controller

1. The chiller shall have distributed control consisting of a unit controller, a compressor controller and a 15-inch super VGA color touch screen for operator interface with the control system. The touch screen shall have graphics clearly depicting the chiller status, operating data, including water temperatures, percent RLA, water setpoint, alarm status and have STOP and AUTO control buttons. The operator interface touch screen shall have inherent trend logging capabilities, which are transferable to other PC management systems such as an Excel spreadsheet via a USB port. Active trend logging data shall be available for viewing in 20 minute, 2 hour or 8 hour intervals. A full 24 hours of history is downloadable via a USB port. The following trended parameters shall be displayed:
 - a. • Entering and leaving chilled water temps
 - b. • Entering and leaving condenser water temps
 - c. • Evaporator saturated refrigerant pressure
 - d. • Condenser saturated refrigerant pressure
 - e. • Net oil pressure
 - f. • % rated load amps
2. Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARKS ® network via one of the data link / physical layers listed below to communicate seamlessly with the existing BMS. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list. eXternal Interface File (XIF) shall be provided with the chiller submittal data. All communication from the chiller unit controller

as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

- a. • BACnet MS/TP master (Clause 9)
 - b. • BACnet IP, (Annex J)
 - c. • BACnet ISO 8802-3, (Ethernet)
 - d. • LONMARKS FTT-10A. The unit controller shall be LONMARKS® certified.
3. Unit setpoints shall be viewable on screens and changeable after insertion of a password. complete unit operating and maintenance instructions shall be viewable on the touch screen and be downloadable via an onboard USB port. In addition to the trended items above, other real-time operating parameters are also shown on the touch screen. These items can be displayed in two ways: by chiller graphic showing each component or from a color-coded, bar chart format. At a minimum, the following critical areas must be monitored:
- a. • Oil sump temperature
 - b. • Oil feed line temperature
 - c. • Evaporator saturated refrigerant temperature
 - d. • Suction temperature
 - e. • Condenser saturated refrigerant temperature
 - f. • Discharge temperature
 - g. • Liquid line temperature
4. Automatic corrective action to reduce unnecessary cycling shall be accomplished through pre-emptive control of low evaporator or high discharge pressure conditions to keep the unit operating through ancillary transient conditions.
5. Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARKS® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier:
- a. • BACnet MS/TP master (Clause 9)
 - b. • BACnet IP, (Annex J)
 - c. • BACnet ISO 8802-3, (Ethernet)
 - d. • LONMARKS FTT-10A. The unit controller shall be LONMARKS® certified.
6. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
7. eXternal Interface File (XIF) shall be provided with the chiller submittal data. All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A

BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

2.05 MISCELLANEOUS ITEMS:

- A. Pump-out System: The unit shall be equipped with a pump-out system complete with a transfer pump, condensing unit, and storage vessel constructed according to ASME Code for Unfired Pressure Vessels and shall bear the National Board stamp. If the design of the unit allows the charge to be transferred to and isolated in the main condenser, then a pump-out system is not required. Transfer of refrigerant charge shall be accomplished by either main compressor operation, migration, or gravity flow. Isolation shall be accomplished with valves located at the inlet and outlet of the condenser. The main condenser shall be sized to contain the refrigerant charge at 90°F according to ANSI-ASHRAE 15.A.
- B. Purge System (Negative Pressure Chillers Only):
 1. The chiller manufacturer shall provide a separate high efficiency purge system that operates independently of the unit and can be operated while the unit is off. The system shall consist of an air-cooled condensing unit, purge condensing tank, pump-out compressor and control system.
 2. A dedicated condensing unit shall be provided with the purge system to provide a cooling source whether or not the chiller is running. The condensing unit shall provide a low purge coil temperature to result in a maximum loss of 0.1 pounds of refrigerant per pound of purged air.
 3. The purge tank shall consist of a cooling coil, filter-drier cores, water separation tube, sight glass, drain, and air discharge port. Air and water are separated from the refrigerant vapor and accumulated in the purge tank.
 4. The pump-out system shall consist of a small compressor and a restriction device located at the pump-out compressor suction connection.
 5. The purge unit shall be connected to a 100% reclaim device.
- C. Vacuum Prevention System (negative pressure chillers only): Chiller manufacturer shall supply and install a vacuum prevention system for each chiller. The system shall constantly maintain 0.05 psig inside the vessel during non-operational periods. The system shall consist of a precision pressure controller, two silicon blanket heaters, a pressure transducer, and solid-state safety circuit.
- D. Refrigerant Detection Device (negative pressure chillers only): Chiller manufacturer shall supply and install a refrigerant detection device and alarm capable of monitoring refrigerant at a level of 10 ppm. Due to the critical nature of this device and possible owner liability, the chiller manufacturer shall guarantee and maintain the detection monitor for five years after owner acceptance of the system.
- E. Waffle type vibration pads for field mounting under unit feet.

- F. ARI/ETL/CETL Approval.
- G. OSHPD Certification: The chiller shall be OSHPD Pre-Approved per OSP-0116-10 and be so labeled. The chiller shall meet a minimum seismic design spectral response acceleration of 1.60 SDS. The chiller must be mounted to a rigid base and may use neoprene waffle vibration pads.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in strict accordance with manufacturer's requirements, submittal drawings, and contract documents.
- B. A 20-mesh strainer shall be placed in the supply water line just prior to the inlet of the evaporator. Care shall be exercised when welding pipe or flanges to the evaporator to prevent any slag from entering the vessel.
- C. Adjust and level chiller in alignment on supports.
- D. Arrange piping to enable dismantling and permit head removal for tube cleaning.
- E. Coordinate electrical installation with electrical contractor.
- F. Coordinate controls with control contractor.
- G. Provide all appurtenances required to ensure a fully operational and functional chiller.
- H. Communication Wiring
 - 1. Conduit shall be installed between each chiller's unit control panel and the building for current and future control wiring for equipment located external to the facility. The conduit installation shall be per all NEC and local electrical codes inclusive of the depth of the conduit and placement of the communications conduit in relation to the chiller's power conduit and water piping. If multiple units are in close proximity, a single conduit from the building LAN may be run to the closest unit. Then conduit shall be extended from the closest chiller control panel to multiple units in a star configuration. Consult the equipment manufacturer regarding cabling options and limitations for multiple units.
 - 2. A minimum capacity CAT 5e Ethernet cable shall be provided in the communications conduit to the chiller from a network switch in the facility. After connecting the conduit to each unit's control panel, the CAT 5e cable shall be extended 3 feet and coiled inside each panel for connection as required for chiller communications. The cable length, continuity,

electrical isolation and installation shall be per NEC requirement and local code requirements for communication cabling running from a building to a location exterior to the building.

- I. Coordinate controls and BMS interface with controls contractor.
- J. Provide all material required for a fully operational and functional chiller.

3.02 START-UP

- A. Units shall be field charged with refrigerant.
- B. Factory Start-Up Services: Provide factory supervised start-up on-site for a minimum of two working days ensure proper operation of the equipment. During the period of start-up, the factory authorized technician shall instruct the Agency's representative in proper care and operation of the equipment.
- C. The contractor shall furnish manufacturer complete submittal wiring diagrams of the unit as applicable for field maintenance and service

END OF SECTION 23 64 26

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including Division 0, Contract Requirements, and Division 1, General Requirements, are a part of this Section and shall be binding on the Contractor and /or Subcontractor who performs this work. Note also all addenda.
- B. The requirements in Section 26 00 00 shall govern the work under all Sections of Divisions 26.

1.2 SCOPE OF WORK:

- A. Scope of work consists of installation of materials to be furnished under these Specifications and without limiting generality thereof consists of furnishing labor, materials, equipment, hoisting, plant, transportation, rigging, staging, appurtenances, and services necessary and/or incidental to properly complete all electrical work as shown on drawings, as described in the Specifications or as reasonably inferred from either as being required in opinion of the Engineer.
- B. Work Included: Provide complete electrical services where shown on the drawings, as specified herein and as needed for a complete and proper installation including but not necessarily limited to:
 - 1. Additions and modifications to existing 5 KV medium voltage switchgear.
 - 2. New 5 KV medium voltage switchgear.
 - 3. Feeder to new 5 KV medium voltage switchgear.
 - 4. Medium voltage and low voltage branch circuit wiring.
 - 5. Raceways.
 - 6. Grounding.

1.3 SITE CONDITIONS:

- A. Prior to submitting bid, visit the site and identify existing conditions and difficulties that will affect work called for by the Contract Documents.
- B. No compensation will be granted for additional work caused by unfamiliarity with site conditions that are visible or readily construed by experienced observers.
- C. The Contractor shall verify and obtain all necessary dimensions at the site.

1.4 DEFINITIONS:

- A. Furnish: The word "furnish" is used to mean "supply and deliver the referenced item to the project site, ready for unloading, unpacking, assembly, and installation".
- B. Install: The word "install" is used to describe operations at the project site involving the referenced item including the actual "unloading, unpacking, assembly, erection, placing,

anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations".

- C. Normally Occupied: The words "normally occupied" are used to mean "all rooms within a building except for crawlspaces, underground tunnels, attic spaces, mechanical rooms, telephone rooms, data distribution rooms, and electrical rooms".
- D. Or Approved Equal: The words "or approved equal" are used to mean "any product which in the opinion of the Engineer is essentially equal in quality, size, arrangement, appearance, construction, and performance to that product specified or shown on the drawings".
- E. Provide: The word "provide" means "to furnish and install the referenced item, complete and ready for the intended use".
- F. Remove: The word "remove" means "to disconnect from its present position, remove from the project site, and to dispose of in a legal manner".

1.5 QUALITY ASSURANCE:

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of the Contract Documents.
- B. Codes and Regulations:
 - 1. In addition to complying with the specified requirements, comply with all Federal, State and Local Codes wherever applicable including the following: 2018 Connecticut State Building Code, 2015 IBC, 2018 Connecticut Fire Safety Code , 2015 International Fire Code, 2013 NFPA 72 National Fire Alarm Code, 2017 NFPA 70 National Electrical Code, 2010 NFPA 110 Standard for Emergency and Standby Power Systems, 2015 International Energy Conservation Code, ICC/ANSI A117.1-2009 Accessible and Usable Buildings and Facilities, and ADA.
 - 2. Comply with the requirements of the Local Authority Having Jurisdiction.
 - 3. Materials and equipment shall be UL listed where standard has been established.
 - 4. Perform tests required by specifications, Engineer's instructions, laws, ordinances or public authorities, approvals, and give Owner timely notice. Notify the Owner of dates for inspection by other authorities.
 - 5. In the event of conflict between or among specified requirements and pertinent regulations, the more stringent requirement will govern.
 - 6. Reference made to codes and standards shall be interpreted as minimum requirements. Provide and perform work in excess of codes and standards as indicated by drawings or specifications.
- C. Prior to bidding, the Contractor shall give written notice to the Engineer of any materials, equipment, or apparatus believed in the opinion of said Contractor, to be inadequate or unsuitable for the installation, or in violation of laws, ordinances, rules, or regulations of authorities having jurisdiction. The Contractor shall also give written notice to the Engineer of any items, materials, equipment, or work believed in the opinion of said Contractor, to be omitted from the Contract Documents. In the absence of such written notice, it is mutually agreed that Contractor has

included the cost of all required items in his bid and that he will be responsible for approved satisfactory functioning of systems without further compensation.

1.6 SUBMITTALS:

- A. Comply with the requirements of Division 1 for submittal procedures.
- B. Product data: after the Contractor has received the Owner's Notice to Proceed, submit an electronic (PDF) copy of the following:
 - 1. Materials list of all items proposed to be provided.
 - 2. Manufacturer's specifications, catalog cuts, performance curves, electrical characteristics, wiring diagrams, equipment dimensions and weights, and other data for each item proposed to be provided as needed to prove compliance with the specified requirements.
 - 3. Shop drawings and other data as required to indicate method of installing and attaching equipment.
- D. Place a permanent label or title block on each submittal for identification. Indicate the name of the entity that prepared each submittal on the label or title block.
 - 1. Include the following information on the label for processing and recording action taken:
 - a. Project name, location, and address
 - b. Date
 - c. Name and address of Engineer
 - d. Name and address of Contractor
 - e. Name and address of Sub-Contractor
 - f. Name and address of supplier(s)
 - g. Name of manufacturer(s)
 - h. Number and title of appropriate Specification section.
- E. Data sheets and catalog cuts, etc. contained in submittals shall be clearly marked in ink indicating specific service or application for which material or equipment is to be used. Data of a general nature and not clearly defining the service or application for which the proposed item is to be used will not be accepted.
- F. Submit for review complete diagrams of systems prepared by equipment manufacturer showing connections and equipment. Standard wiring diagrams shall be modified where necessary to specific system.
- G. Prior to forwarding submittals and shop drawings for review by the Architect and Engineer, the Contractor shall thoroughly check each submittal, reject those not conforming to the specifications, and indicate by his signature that the submittals in his opinion meet the contract requirements.

- H. Intent of Shop Drawings and product data review is to check for capacity, rating and certain construction features, ensure that work meets requirements of Contract Documents regarding information that pertains to fabrication processes or means, methods, techniques, sequences and procedures of construction, and for coordination of work between trades.
- I. Submittal review shall not diminish responsibility under this contract for dimensional coordination, quantities, installation, piping, supports, access, service and errors, nor for deviations from requirements of contract documents. Noting errors while overlooking others will not excuse proceeding in error. Requirements of contract documents are not limited, waived, nor superseded by shop drawing review.
- J. Equipment variations: Where no specific make or material, apparatus or appliance is mentioned in the Contract Documents, any first class product made by a reputable manufacturer may be used, providing it conforms to the requirements of these specifications and meets the approval of the Engineer.
- K. Equipment alternates, substitutions, and deviations:
1. Wherever more than one manufacturer is mentioned in the specifications or on the drawings, any of those named shall be considered equally acceptable to that on upon which design was based, and providing all aspects of the specification are met insofar as quality, construction, performance, space requirements, noise levels and special accessories or materials, any of those named may be included in Contractor's bid.
 2. Bidders wishing to obtain approval on brands other than those specified by name shall submit their request to the Architect and Engineer not less than ten (10) business days before the date fixed for opening of bids. No substitutions will be entertained after this time. Approval by the Architect and Engineer will be in the form of an Addendum to the specifications issued to all prospective bidders, indicating that the additional brand or brands are approved as equal to those specified so far as the requirements of the project are concerned.
 3. Alternate equipment to that specified or shown on the drawings, as proposed to be provided by the contractor, must be essentially equal in quality, size, construction, and performance to that item specified or shown on the drawings.
 4. Submittals for alternate equipment shall list all deviations and differences from the specified equipment. Failure to submit this list will result in rejection of the submittal. Any deviations and differences not listed but discovered after installation shall be rectified as directed by the Engineer at the Contractor's cost.
 5. Furnish samples of alternate equipment proposed to be provided when so requested by the Architect or Engineer.
 6. Where the Contractor proposes to use an item of equipment which differs from that upon which design was based, which requires any redesign of the structure, partitions, foundations, piping, wiring or of any other part of Mechanical, Electrical or Architectural Layout, all such redesign, new drawings or detailing required shall be prepared by Contractor at his own expense for approval of the Architect and Engineer.
 7. Where approved substitutions or deviations require a different quantity, size or arrangement of structural supports, wiring, conduit, piping, ductwork, and equipment from that upon which design was based, all additional items required by the systems shall, with the approval of the Architect and Engineer, be furnished by Contractor at no additional cost to Owner.

- L. Allow sufficient time so that the delivery and installation of equipment will not be delayed as a result of the time required to review, process and transmit submittals, including resubmittals. Failure by the Contractor to transmit submittals to the Architect and Engineer in ample time for review and processing shall not entitle him to an extension of the Contract Time and no claim for an extension of time by reason of such default will be allowed.

- M. Submittals, shop drawings, and samples will be reviewed with reasonable promptness and will be stamped indicating appropriate action as follows:
 - 1. “No Exceptions Taken” means that fabrication, manufacture, or construction may proceed providing submittal complies with contract documents.

 - 2. “Amend as Noted” means that fabrication, manufacture, or construction may proceed, providing the submittal complies with Engineer’s notations and contract documents.

 - 3. “Resubmit” means that submittal, or equipment proposed to be provided, does not comply fully with the contract documents and that fabrication, manufacture, or construction shall not proceed. Resubmit in accordance with the Engineer’s notations and contract documents.

 - 4. “Rejected” means that submittal does not comply with contract documents, or that equipment proposed to be provided does not comply with the specified requirements or is not equal or better in quality and performance than that item specified. Fabrication, manufacture, or construction shall not proceed. Resubmit in accordance with the contract documents and specified requirements.

- N. If material or equipment is installed prior to review, or without review, it shall be removed and replaced at no extra charge to the Owner if, in the opinion of the Architect and Engineer, the material or equipment is not in compliance with the Contract Documents.

1.7 AS-BUILT DRAWINGS:

- A. Maintain a clean, undamaged set of black line white-prints of Contract Drawings and Shop Drawings at the job site. Protect as-built drawings from deterioration and loss in a secure location. Provide access to as-built drawings for reference during normal working hours by the Owner, Architect, Engineer, and Authority Having Jurisdiction.

- B. As work progresses mark the As-built drawings to show the actual installation where the installation varies from the work as originally shown, whether resulting from Addenda, Change Order, approved submittals, or changes made due to field conditions. Mark whichever drawing is most appropriate for showing conditions fully and accurately. Where shop drawings are used, record a cross reference at the corresponding location on the Contract Drawings. Give particular attention to items concealed within the structure or buried below grade.
 - 1. Mark as-built drawing sets with colored erasable pencils: using separate colors to distinguish between different systems.

 - 2. Include dimensioned locations of conduit runs buried below floor slabs and buried beyond the building footprint.

 - 3. Note related change order numbers where applicable.

- C. At the completion of work prepare a new set of black line white-print As-built Drawings, of work as actually installed, incorporating addenda, changes made due to approved submittals, change order work, field changes, and added data, all as shown on the marked-up record drawings maintained at the site. Date the set and clearly mark it as "As-built Drawings".
- E. Furnish two sets of the As-built Drawings to the Architect and Engineer.

1.8 OPERATING AND MAINTENANCE MANUALS:

- A. Upon completion of the work of this Contract, deliver to the Architect and Engineer four (4) copies of an Operation and Maintenance (O & M) Manual. Organize operating and maintenance data into suitable sets of manageable size. Bind properly indexed data in individual heavy-duty 2-inch, 3-ring vinyl covered binders, with pocket folders for folded sheet information. Include a separate section for each system or sub-system. Sections shall be separated by heavy plastic dividers with tabs that identify the material in each section. Place a permanent label or title block on each binder for identification.
 - 1. Include the following information on the label:
 - a. O & M Manual for:
Groton, CT.
 - b. Date
 - c. Name and address of Engineer
 - d. Name and address of Contractor
 - e. Name and address of Sub-Contractor
- B. Provide the following in each manual:
 - 1. Table of Contents
 - 2. Listing of all service agents with addresses and telephone numbers
 - 3. Description of systems operation
 - 4. Emergency instructions for equipment and/or systems where appropriate
 - 5. Wiring diagrams and piping diagrams specific to systems installed.
 - 6. Manufacturers' operating and maintenance instructions for each piece of equipment installed
 - 7. Inspection procedures
 - 8. Spare parts list
 - 9. Copies of all panelboard circuit indexes.
 - 10. Copies of measurements taken where specified elsewhere in the Contract Documents
 - 11. Copies of all warranties and guarantees.
 - 12. Copies of submittals and shop drawings.

1.9 GUARANTEE AND WARRANTIES:

- A. Obtain in Owner's name written equipment and material warranties offered in manufacturer's published product data without exclusion or limitation.

- B. Guarantee work of this Contract in writing for a period of 18 months from the date of substantial completion. Repair or replace defective materials, equipment, workmanship and installation that develop within this period, promptly and to Owner's satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within contract price.
- C. Replace material or equipment that requires excessive service during guarantee period, as defined and as directed by the Architect and Engineer.
- D. Submit guarantee to the Owner before final payment.

1.10 LAWS, ORDINANCES, PERMITS, AND FEES:

- A. Give all necessary notices, obtain all permits and pay all taxes, fees and other costs in connection with the work; file all necessary plans, prepare all documents and obtain all necessary approvals of all Regulation Authorities; obtain all required Certificates of Occupancy and/or Inspections required for the work and deliver same to the Owner before requests for acceptance and final payment for the work.
- B. Include in the work, without extra cost to the Owner, all labor, materials, services, apparatus, drawings (in addition to Contract Documents and Drawings) required to comply with all applicable laws, ordinances, rules and regulations.

1.11 CORRELATION OF DRAWINGS AND SPECIFICATIONS

- A. In general, the Specifications will describe the "quality" of the work and the Drawings the "extent" of the work. The Drawings and Specifications are cooperative and supplementary; however, and each item of the work is not necessarily mentioned in both the Drawings and Specifications. All work necessary to complete the project, so described, is to be included in this contract.
- B. In case of disagreement between Drawings and Specifications, or within either document itself, the better quality or greater quantity of work shall be estimated and the matter drawn to the Architect's and Engineer's attention for decision and/or adjustment. Any work done by any Contractor without consulting the Engineer, when the same requires a decision and/or adjustment, shall be done at the Contractor's risk.
- C. Drawings are diagrammatic and indicate general arrangement of systems and work included in Contract. Information and components shown on diagrams but not on plans, and vice versa, shall apply or shall be provided as though expressly required on both. It is not intended that every fitting or component be specified or shown on drawings; however, Contract Documents require provision of all components and materials necessary for a complete and operational installation, whether or not indicated or specified.
- D. Do not scale Drawings. Scale indicated on Drawings is for establishing reference points only. Actual field conditions shall govern all dimensions. The Contractor shall verify all dimensions at the project site.

- E. In all cases where the Contract Documents refer to equipment or apparatus in singular number, it is intended that such reference include as many such items that are required to complete the work.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP:

- A. Provide only materials that are new and of type and quality specified. Where Underwriters' Laboratories, Inc. have established standards for such materials, provide only materials bearing the UL label.
- B. Provide accessories, materials and equipment necessary to make installation complete in every detail, and to conform to manufacturers' latest installation instructions, under this Contract whether or not specifically shown on drawings or specified herein.
- C. All component parts of each item of equipment shall bear the manufacturers' nameplate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc. in order to facilitate maintenance or replacement. Contractors or Distributors nameplates shall not be fixed to items of equipment and are not an acceptable alternate to the manufacturer's nameplate data.
- D. No materials or equipment used shall be discontinued or about to be discontinued items.
- E. The Engineer shall have the right to reject any part of the work in case the material or workmanship is not of satisfactory quality. Any work or material deemed unacceptable by the Engineer shall be removed and replaced with acceptable work and material as defined by the Architect and Engineer, and at no additional expense to the Owner.

2.2 PROTECTION:

- A. Work performed by the Contractor shall include protecting the work and materials of all other Contractors from damage by work or workmen, and shall include making good any and all damage thus caused.
- B. The Contractor shall be responsible for work and equipment until finally inspected, tested and accepted. Protect work against vandalism, theft, weather, injury or damage, and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with approved covers, caps or plugs during construction to exclude dust, dirt, moisture, plaster, mortar, or general construction debris. Note - duct tape is not an acceptable means of protecting open conduit and pipe ends.
- C. Work shall include receiving, unloading, uncrating, storing, protecting, setting in place and completely connecting any motor starters and/or control equipment having mechanical/electrical service connections which are furnished by Owner or furnished by others.
- D. Work shall include exercising special care in handling and protecting equipment and fixtures. Any equipment and fixtures which are missing, lost, stolen, or damaged by reason of the Contractor's

failure to provide adequate protection shall be replaced by that Contractor at no additional cost to the Owner.

2.3 SCAFFOLDING, RIGGING, HOISTING:

- A. Work shall include all scaffolding, rigging, hoisting and services necessary for delivery and erection of equipment into or onto the site and/or building. Remove all scaffolding, rigging, and hoisting equipment from the site when no longer needed.

2.4 CUTTING AND PATCHING:

- A. Cutting and patching for all electrical work shall be performed in accordance with Division 1 of these Specifications.

2.5 SLEEVES AND OPENINGS:

- A. The Electrical Contractor shall provide all necessary sleeves and openings as required to permit the installation of the electrical systems.

2.6 PAINTING:

- A. All painting of electrical work shall be performed in accordance with Division 9 of these Specifications, unless otherwise specified.

2.7 ELECTRICAL MOTOR STARTERS AND VARIABLE FREQUENCY DRIVES (VFD'S):

- A. Motor starters and variable frequency drives (VFD'S) shall be furnished by each respective trade for motor driven equipment provided by them. The Electrical Contractor shall install the starters and VFD'S, and shall provide all power wiring to the starters and VFD'S, and from the starters and VFD'S to the motors they control.
- B. Motor starters and VFD'S shall conform to requirements of NEC, NEMA, UL, CSA, and ANSI and shall be suitable for the required horsepower, duty, voltage, phase, frequency, service, and location. All starters and VFD'S shall be furnished in NEMA enclosures suitable for the environment in which they are to be located.

2.8 BASES AND SUPPORTS:

- A. Provide all necessary supports, rails, framing, bases, and piers required for the installation of equipment provided under this contract.
- B. Unless otherwise shown, all equipment shall be securely attached to the building structure in an acceptable manner. Attachments shall be of a strong and durable nature; any attachments that are insufficient in the opinion of the Architect or Engineer shall be replaced as directed at no additional cost to the Owner.

2.9 SEISMIC RESTRAINTS:

- A. Provide seismic restraints for all electrical system components in accordance with the 2018 Connecticut State Building Code.

- B. Contractor shall have the following responsibilities:
 - 1. Determine seismic restraint sizes and locations required by code.
 - 2. Provide and install isolation systems and seismic restraints.
 - 2. Provide installation instructions, drawings and field supervision to assure proper installation and performance.

- C. Installations shall be designed to safely accept external forces of one-half “G” load in any direction for all rigidly supported equipment without failure and permanent displacement of the equipment. Life safety equipment such as the emergency generator, transfer switches, emergency power feeders, and emergency power panelboards shall be capable of safely accepting external forces up to one “G” load in any direction without permanent displacement of the supported equipment.

2.10 SLEEVES, INSERTS AND ANCHOR BOLTS:

- A. The Contractor shall provide and shall be held responsible for the location and position of all sleeves, inserts, and anchor bolts required by his work. Failure to do so, which requires cutting and patching of finished work, shall be done at no additional cost to the Owner.

2.11 FIRE STOPPING:

- A. All sleeves shall be packed with damming material and sealed. Sealant shall allow for movement without cracking and shall be 3M brand Fire Barrier Caulk CP25 or approved equal.

- B. Provide fire stopping at all fire or smoke rated wall or fire rated floor penetrations in order to maintain its original integrity. The materials and methods must be tested and listed or approved by Underwriters Laboratories, Factory Mutual or some other recognized authority. The fire stopping performance must be evaluated in accordance with ASTM-E814 test method. The Contractor shall use 3M Family of Products including, but not limited to the following:
 - 1. CP25 caulk fire barrier compound.
 - 2. CS-195 fire resistive composite panel for large openings.
 - 3. FS-195 wrap/strip to fire stop plastic pipe.
 - 4. PSS-7900 systems for circular, rectangular, and square openings.
 - 5. MPP-4S+ moldable putty pads for electrical outlet boxes.

- C. The above 3M products and systems shall be submitted for review by the Engineer and properly applied in the field in accordance with the Manufacturer's recommended procedures.

2.12 LUBRICATION:

- A. All equipment installed under this contract having moving parts shall and requiring lubrication shall be properly lubricated according to the manufacturer's instructions prior to operation and testing. Any such equipment discovered to have been operated prior to lubrication by the Contractor shall be subject to rejection and replacement at no additional cost to the Owner.

2.13 ACCESS PANELS:

- A. Provide access panels for electrical equipment which is not readily accessible. Such equipment includes items above hung ceilings which are not readily removable and items installed within walls, inside chases, or inside dead cavity spaces.
- B. Access panels shall be of sufficient size to permit easy replacement and servicing of electrical equipment.
- C. Access panels shall bear the same or greater fire rating as the wall or ceiling in which they are installed.

2.14 OTHER MATERIALS:

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Architect and Engineer.
- B. Provide miscellaneous hardware and support accessories, including channels, support rods, nuts, bolts, screws, and other such items, with galvanized or cadmium plated finish, or other approved rust inhibiting coatings.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Unless specifically noted or shown otherwise, install all equipment and material specified herein or shown on drawings whether or not specifically itemized herein.
- B. Check equipment and material delivered to the project site and verify that it is in conformance with the approved submittals prior to installation.

3.2 SURFACE CONDITIONS:

- A. Examine the areas and conditions under which work of this Contract will be performed. Correct conditions detrimental to timely and proper completion of the work. Do not proceed until unsatisfactory conditions are corrected.

3.3 PREPARATION:

- A. Coordinate:
 - 1. Coordinate as necessary with other trades to assure proper and adequate provisions in the work of those trades for interface with the work of this Contract. Each Contractor shall furnish all information necessary to permit work of other trades to be installed in a satisfactory manner.

2. Coordinate delivery of equipment to project prior to installation. Any equipment stored for an extended period of time prior to installation may be subject to rejection by the Architect or Engineer.
 3. Coordinate the installation of items with the schedule for work of other trades to prevent unnecessary delays in the total work.
 4. Where electrical equipment is shown in conflict with locations of structural members or other equipment, provide required supports, offsets, bends, or tees as required to clear the encroachment.
 5. No conduit, cable(s), boxes, etc., shall be installed until the entire run has been checked for clearances and the work has been coordinated between all the trades. Each tradesman shall be responsible for taking his own field measurements and maintaining proper clearance from the Owner's equipment and the work of other trades, and for coordinating his work with that of other Contractors. Furnish all necessary information, dimensions, templates, etc. in order that a properly coordinated job will result.
 6. If due to lack of coordination and foresight by the Contractor, equipment must be relocated or extra work performed, all costs shall be the responsibility of the Contractor and may not be passed through to the Owner.
- B. Unload equipment and materials delivered to the site. Pay cost for rigging, hoisting, lowering and moving electrical equipment on site, in building, or on roof. During construction provide protection against moisture, dust accumulation, and physical damage of equipment. Provide temporary heaters within units as required to evaporate excessive moisture and provide ventilation as required.
- C. Certain present building clearances are available for handling equipment. All equipment shall be delivered knocked down as required to clear space limitations on site and within the building.
- D. Unless noted otherwise the Contractor shall set all equipment level, plumb, and secure prior to making connections to other equipment or systems.
- E. Data indicated on the drawings and in these Specifications are as exact as could be secured, but their absolute accuracy is not warranted. The exact locations, distances, levels and other conditions will be governed by actual construction and the drawings and specifications should be used only for guidance in such regard.
- F. Verify all measurements at the building. No extra compensation will be allowed because of differences between work shown on the drawings and actual measurements at the site of construction.
- G. The drawings are diagrammatic, but are required to be followed as closely as actual construction and work of other trades will permit. Where deviations are required to conform to actual construction and the work of other trades, make such deviations without additional cost to the Owner.

3.4 ACCESSIBILITY:

- A. Locate all equipment which must be serviced, operated or maintained, in fully accessible positions including but not limited to: controllers, motor starters, disconnect switches, transformers, panelboards, switchgear, etc. Provide access panels as required for equipment access.
- B. Failure by the Contractor to locate equipment and arrange the installation to allow for adequate access and clearance for maintenance and servicing shall result in rejection of the installation and the disassembly, relocation and re-assembly of the installation shall be done by the Contractor at no additional cost to the Owner.

3.5 CLEANING AND PROTECTING PIPING, CONDUITS AND EQUIPMENT:

- A. Thoroughly clean all piping, conduit, and equipment of all foreign substances inside and out before installation.
- B. Plug open pipe and conduit ends during construction with approved plugs or caps to exclude dust, moisture, plaster or mortar etc. Note - using duct tape to cover conduit and pipe ends is not an acceptable means of excluding construction debris and may result in rejection of the installation with remedial action to be taken by the Contractor at no additional cost.
- C. If any part of a conduit system should be blocked by any foreign matter after being placed in operation, the system shall be disconnected, cleaned and reconnected wherever necessary in order to locate and remove the obstruction(s). Any work damaged in the course of removing obstructions shall be repaired or replaced at no additional cost to the Owner.

3.6 PROJECT COMPLETION:

- A. Upon completion of the work, remove all waste, rubbish and other materials left as a result of operations and leave the premises in clean condition.
- B. Thoroughly clean all exposed portions of the electrical installation, removing all traces of soil, labels, grease, oil and other foreign material, and using only the type cleaner recommended by the manufacturer of the item being cleaned.
- C. Vacuum all exteriors of equipment and interiors of equipment having accessible interior compartments to remove all dust, dirt, cable clippings, construction debris, etc.
- D. Equipment with damage to painted finish shall be repaired to satisfaction of the Owner. Equipment that cannot be satisfactorily repaired shall be replaced at no cost to the Owner.
- E. Upon completion of all work and of all tests, the Contractor shall furnish the necessary skilled labor and helpers for operating the system and equipment for a period of one (1) day or eight (8) hours, or as otherwise specified. During this period, instruct the Owner or his representative fully in the operation, adjustment and maintenance of all equipment furnished. Provide at least forty-eight (48) hours notice to the Owner in advance of this period.
- F. Thoroughly indoctrinate the Owner's operation and maintenance personnel in the contents of the as-built drawings and the operations and maintenance manual required to be submitted under these Specifications.

3.7 INSTRUCTION PERIOD:

- A. Prepare written instruction frames for the proper maintenance and operation of any special equipment furnished and installed under this Contract.
- B. The contractor shall arrange for on-site instruction of the Owner's representatives by manufacturers of all major items of equipment. The instruction periods shall be consecutive and shall be held after the installations are complete, tested and balanced and the approved documentation is available. The contractor shall be responsible for attendance of the manufacturer's technical representatives and shall coordinate program timing with the Owner.
- C. In addition to normal operation, the Owner's representatives shall be instructed on routine maintenance and trouble-shooting.

END OF SECTION 26 00 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including Division 0, Contract Requirements, and Division 1, General Requirements, are a part of this Section and shall be binding on the Contractor and /or Subcontractor who performs this work. Note also all addenda.
- B. Section 26 00 00 General Electrical shall also govern the work under this Section.
- C. This Section includes requirements that are binding on other Sections of Divisions 26.
- D. Examine all drawings, data, and coordinate the work of this Section with all related and adjoining work.

1.2 SCOPE OF WORK:

- A. Scope of work consists of installation of materials to be furnished under this Section, and without limiting generality thereof consists of furnishing labor, materials, equipment, hoisting, plant, transportation, rigging, staging, appurtenances, and services necessary and/or incidental to properly complete all electrical work as shown on the drawings, as described in these specifications or as reasonably inferred from either as being required in opinion of the Architect and Engineer.
- B. Work Included: Provide complete electrical services where shown on the drawings, as specified herein and as needed for a complete and proper installation including but not necessarily limited to:
 - 1. General
 - 2. Conduits, Raceways
 - 3. Equipment Labeling
 - 4. Wire and Cables
 - 5. Outlet Boxes, Junction Boxes, Pull Boxes, Wireways
 - 6. Cabinets
 - 7. Disconnect Switches
 - 8. Supporting Devices
 - 9. Fuses
 - 10. Grounding

1.3 QUALITY ASSURANCE:

- A. Refer to Section 26 00 00.

1.4 SUBMITTALS:

- A. Shop Drawings, Product Data, and Certifications that products conform to requirements: Submit for all items provided as part of the Work of this Section, including but not limited to those items listed in Paragraph 1.2, B above.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Provide only materials that are new and of type and quality specified, or approved equal. Where Underwriters' Laboratories, Inc. have established standards for such materials, provide only materials bearing the UL label.
- B. Provide materials and equipment necessary to make installation complete in every detail, and to conform to manufacturers' latest installation instructions, under this contract whether or not specifically shown on drawings or specified herein.

2.2 RACEWAYS:

A. Rigid Steel Conduit:

1. Shall be manufactured from high strength strip steel, shall be hot dipped galvanized with threads galvanized after cutting, and shall be chromated to form an additional protective layer. Rigid steel conduits shall be UL listed, shall meet the requirements of ANSI C80.1, and shall be as manufactured by Allied Tube and Conduit, Wheatland, or Calconduit.
2. Shall be used for work in hazardous (classified) locations.
3. Shall be used in outdoor locations where conduit is exposed to physical damage, sunlight or weather.
4. Shall be used for underground work.
5. Shall be used for horizontal and vertical underground sweeps, horizontal and vertical sweeps below concrete slabs, and for penetrations through concrete slabs.
6. Fittings, couplings and connectors shall be threaded and galvanized or cadmium plated.

B. Intermediate Steel Conduit:

1. Shall be manufactured from high strength flat steel that is cold-formed and electrically welded into a uniform tube, shall be hot dipped galvanized with threads galvanized after cutting, and shall be chromated to form an additional protective layer. Intermediate steel conduit shall be UL listed, shall meet the requirements of ANSI C80.6, and shall be as manufactured by Allied Tube and Conduit, Wheatland, or Republic Conduit.
2. Shall be used in interior locations where conduit is exposed to physical damage, or corrosive or wet environments.
3. Fittings, couplings and connectors shall be threaded and galvanized or cadmium plated.

C. Electrical Metallic Tubing:

1. Shall be manufactured from high grade mild strip steel, shall be hot dipped galvanized, and shall be chromated and lacquered to form additional protective layer. EMT conduit shall

conform to UL 797 and ANSI C80.3 and shall be as manufactured by Allied Tube and Conduit, Wheatland, or Republic Conduit.

2. Connectors and couplings shall be galvanized steel set screw type. Provide gland compression type couplings and connectors for exposed work in wet locations.
3. Shall be used for all interior feeders except where specified differently or noted differently on the drawings. Provide insulated throat grounding bushings for all feeder conduit connections to switchboards, panelboards, transformers, disconnect switches, wireways, and pull boxes.
4. Shall be used for all interior wiring in masonry partitions, above non-accessible ceilings, and where exposed to view.
5. Shall be used for all branch circuit homeruns and closing connections to panelboards.
6. Shall be used for all branch circuits feeding HVAC equipment and equipment requiring 3-Phase power.
7. Shall not be embedded in concrete slabs.

D. Flexible Steel Conduit:

1. Shall be full wall steel flexible conduit, shall be manufactured from high grade strip steel and shall be hot dipped in a molten zinc bath. The steel strip shall be formed into interlocking convolutions that are continuously joined, metal to metal, assuring continuous grounding contact. Flexible steel conduit shall be UL listed and shall be as manufactured by AFC Cable Systems, Greenfield, Anaconda, or Electri-Flex.
2. Flexible steel conduit fittings shall be zinc plated malleable iron squeeze type connectors and zinc plated malleable iron combination couplings
3. May be used in short lengths where EMT cannot be installed due to interferences and obstacles.
4. Provide for final connections to motor driven equipment, transformers, recessed light fixtures, chain hung light fixtures, or where subject to vibration.

E. Liquidtight Flexible Steel Conduit:

1. Shall be similar to flexible steel conduit, but with pressure-extruded moisture and oil-proof outer jacket of gray polyvinyl chloride plastic. Liquidtight flexible steel conduit shall be UL listed (UL 360) and shall be as manufactured by AFC Cable Systems Anaconda, or Electri-Flex.
2. Fittings, couplings and connectors shall be threaded, zinc plated, malleable iron liquidtight type.
3. Provide where located outdoors or in damp or wet areas for final connections to motor driven equipment, or where subject to vibration.
4. Do not use in environmental air plenum spaces.

F. Surface Steel Wireway:

1. Wireways shall be code gauge galvanized steel, manufactured standard sections and fittings, with hinged and/or screw covers, indoors NEMA Type 1/Outdoors NEMA Type 3R, and shall be manufactured by Hoffman, Cooper, Square D, or Wiremold. Wireways shall be sized to code conductor fill requirements and shall be provided as required for job conditions.

2.3 METHODS AND MATERIALS FOR LABELING EQUIPMENT:

- A. Switchgear, Switchgear Circuit Breakers:
 - 1. Non-metallic engraved nameplates shall be used to identify device. Nameplates shall be secured to equipment with two screws or rivets. Adhesive nameplates are not acceptable.
 - 2. Letters shall be white on black background.
 - 3. Nameplate letters shall be 1/4" high.
 - 4. Identification nomenclature shall be in accordance with plans. All name nomenclature shall be submitted for approval.

- B. Identify the covers of all junction boxes, wireways, and pull boxes installed above ceilings and in unfinished spaces with branch circuit or feeder designations. Identification shall be done with black felt tip permanent marker in a neat and readily legible manner.

2.4 MOTOR STARTER/DISCONNECTS AND VFD'S:

- A. Combination motor starter/disconnects and variable frequency drives (VFD's) will be supplied by other trades for motor driven equipment provided by them.

- B. The electrical contractor shall install the starter/disconnects and VFD's, and shall provide all power wiring to the units and from the units to the motors they control.

2.5 LOW VOLTAGE (600V) CONDUCTORS:

- A. Conductors shall be provided in Cerro Wire manufacture or comparable product in General Cable or Republic Wire.

- B. All feeder conductors shall be copper, rated 600 volts 90 deg. C., dry and wet locations, type XHHW-2, color coded.

- C. All branch circuit conductors shall be copper rated 600 volts, 90 deg. C., dry and wet locations, type XHHW-2, color coded. Branch lighting and power conductors shall be soft drawn copper with conductivity of not less than 98 percent of ANSI Standard for annealed copper.

- D. Grounding electrode conductors and bonding conductors shall be soft drawn copper, ASTM B3 solid bare copper for sizes smaller than #8AWG, ASTM B8 stranded bare copper for sizes #8AWG and larger.

- E. Minimum gauge conductors for power and lighting shall be #12 AWG. Increase to #10 AWG for runs exceeding 75'-0", and #8AWG for runs exceeding 150'-0".

- F. Wire Size #8 AWG and larger shall be stranded. Wire of size smaller than #8 AWG shall be solid.

2.6 OUTLET, JUNCTION AND PULL BOXES:

- A. Provide outlet boxes as required for a complete installation including.
- B. The minimum box size for all outlet boxes shall be nominal 4" square x 2 1/8" deep (2-gang) except where noted differently on the drawings. Outlet boxes shall be Crown-type boxes with galvanized steel crushed corner exposed work covers. Provide cast boxes for work exposed to wet locations and where called for on the drawings.
- C. For above ground pull boxes, provide galvanized code-gauge sheet steel units with screwed on covers, of size and shape required to accommodate wires without crowding, and to suit the location. Provide pull boxes as specified herein, as required for job conditions, and as follows:
1. Indoors: NEMA Type 1.
 2. Outdoors or Damp or Wet Locations: NEMA Type 3R.
 3. Hosedown and Splashing Water Locations: NEMA Type 4.

2.7 WIRING DEVICES:

- A. All devices shall be furnished in Hubbell or comparable product in Cooper, Pass & Seymour, or Leviton. Devices specified herein are based on Hubbell unless otherwise noted. Receptacle and switch colors shall be as directed by the Architect and Owner.

B. Lighting Switches:

1. Toggle Type: Extra Heavy Duty industrial grade, flush mounting, quiet operation AC type with abuse resistant colored nylon toggle operator, heat resistant composition plastic housing, silver cadmium oxide contacts and copper alloy spring contact arm. Rated at 120-277 VAC, capable of full capacity on tungsten, fluorescent, or LED lamp load. Designed for side or back wiring with up to No. 10 wire, and with #8 brass terminal screws.

	<u>20 AMP</u>	<u>30 AMP</u>
Single Pole	#HBL1221	#HBL3031
Two Pole	#HBL1222	#HBL3032
Three way	#HBL1223	#HBL3033
Four way	#HBL1224	-

2. Switch with lighted toggle pilot or pilot light toggle: same as toggle type except with clear polycarbonate lighted toggle (light on with load off) or red polycarbonate pilot light toggle (light on with load on).

	<u>20 AMP</u>	<u>30 AMP</u>
Lighted Toggle	#HBL1221ILC	-
Single Pole Pilot Light	#HBL1221PL	#HBL3031PL
Two Pole Pilot Light	#HBL1222PL	#HBL3032PL
Three Way Pilot Light	#HBL1223PL	-

- C. Receptacles:

1. Single and double duplex convenience receptacles shall be extra heavy duty specification grade, 2 pole, 3 wire grounding, NEMA 5-20R, rated 20AMP at 125 Volts AC. Receptacles shall have a one-piece all brass wrap around mounting strap with integral ground contacts and ground tension retaining clips, tandem bypass contact, heat resistant thermoplastic rynite base, and high impact nylon face. Receptacles shall be back and side wired, shall have a back wired green ground terminal, automatic ground clip, and threaded brass square head center rivet assembly.

Single Receptacle #HBL5361
Duplex Receptacle #HBL5362WR

2. Ground Fault Duplex convenience receptacles shall be extra heavy duty specification grade, 2 pole, 3 wire grounding, NEMA 5-20R, rated 20AMP at 125 volts AC. Receptacles shall have a solid brass wrap around mounting strap with pre-tensioned ground contacts, tandem modified bypass contacts, all glass circuit board with conformal coating for superior moisture immunity, 7 noise filtering capacitors, heat resistant thermoplastic base and high impact nylon face. Receptacles shall be side wired and shall have a green ground terminal.

Duplex GFCI Receptacle #GFR5362SG

2.8 FUSES:

- A. Provide current limited, non-renewable fuses in Littelfuse manufacture or comparable product in Bussman or Gould. Fuses shall be UL class J up to 600 Amp and Class L over 600 Amp.
- B. Fuses shall be rated 600V or less A.C., UL listed, and have minimum interrupting rating of 200,000 rms amperes with peak let-through current and maximum clearing values within prescribed UL limits. Fuses for motor feeders or motor circuits shall be Class RK-5 of voltage classification rated for motor with minimum interrupting capacity of 200,000 rms amperes and with minimum time delay of ten seconds at 500%.

2.9 CIRCUIT BREAKERS:

- A. Provide circuit breakers in existing panelboards where called for on the drawings. Circuit breakers shall match the panel voltage and A.I.C. rating.

2.10 ACCESS PANELS:

- A. Provide access panels for electrical equipment and wiring splices which are not readily accessible. This includes electrical equipment and wiring splices installed above hung ceilings which are not readily removable, within walls, inside chases, or inside dead cavity spaces.

2.11 OTHER MATERIALS:

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the contractor subject to the approval of the engineer.

- B. Provide miscellaneous hardware and support accessories, including unistrut, channels, jack chain, support rods, nuts, bolts, screws, and other such items, with galvanized or cadmium plated finish, or other approved rust inhibiting coatings.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Unless specifically noted or shown otherwise, install all equipment and material specified herein or shown on drawings whether or not specifically itemized herein. PART 3 covers particular installation methods and requirements peculiar to certain items and classes of materials and equipment.
- B. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the work. Do not proceed until satisfactory conditions are corrected.
- C. The electrical drawings are diagrammatic, but are required to be followed as closely as actual construction and work of other trades will permit. Where deviations are required to conform with actual construction and the work of the other trades, make such deviations without additional cost to the Owner.
- D. Data indicated on the drawings and in these specifications are as exact as could be secured, but their absolute accuracy is not warranted. The exact locations, distances, levels and other conditions will be governed by actual construction and the drawings and specifications should be used only for guidance in such regard.
- E. Verify all measurements at the building. No extra compensation will be allowed because of differences between work shown on the drawings and actual measurements at the site of construction.
- F. Do not scale drawings. Scale indicated on drawings is for establishing reference points only. Actual field conditions shall govern all dimensions.
- G. Coordinate:
 - 1. Coordinate as necessary with other trades to assure proper and adequate provisions in the work of those trades for interface with the work of this Section.
 - 2. Coordinate delivery of electrical equipment to project prior to installation. Equipment stored for an extended period of time prior to installation may be subject to rejection by Architect.
 - 3. Coordinate the installation of electrical items with the schedule for work of other trades to prevent unnecessary delays in the total work.
 - 4. Where electrical items are shown in conflict with locations of structural members and mechanical or other equipment, provide required supports and wiring to clear the encroachment.
 - 5. Arrange installation to provide access to equipment for easy maintenance and repair.

3.2 INSTALLATION OF RACEWAYS AND FITTINGS:

- A. Install wire and cable in approved raceways as specified and as approved by authorities having jurisdiction.
- B. Run conduit and cable parallel to or at right angles with lines of the building, to present a neat appearance.
 - 1. Make bends with standard conduit elbows or conduit bent to not less than the same radius.
 - 2. Make bends free from dents and flattening.
- C. Provide code sized conduit unless a larger size is shown on the drawings or specified herein. Minimum conduit size shall be ¾" diameter.
- D. Securely and rigidly support conduit throughout the work with approved conduit clips and hangers all in conformance with code seismic requirements.
 - 1. Do not use mechanics wire for supporting conduit or cable.
 - 2. Do not support conduits on hung ceilings or from mechanical or electrical equipment.
 - 3. Steel supports and racks shall be galvanized steel channel and fittings, unistrut or approved equal.
 - 4. Provide clamps and support rods as required.
 - 5. Steel support rods or support bolts for conduits shall be 1/8 inch diameter for each inch or fraction thereof of diameter of conduit size, but no rod or bolt shall be less than ¼" in diameter.
 - 6. Horizontal and vertical conduit supports shall not be more than 10' apart or more than 1' from any fitting.
 - 7. Install conduit and cable so it is not in contact with, or resting on, plumbing, fire protection, or HVAC equipment, piping, or ductwork.
- F. Do not install conduit runs exposed on the building exterior.
- G. Maintain at least 3" clearance between conduits and heating pipes when running parallel to these pipes, and at least 1" clearance when running perpendicular to these pipes.
- H. Provide double locknuts on all conduits terminating in sheet metal enclosures. Provide insulated throat grounding bushings on all feeder conduits.
- I. Provide expansion couplings for rigid metallic and non-metallic conduits where such conduits are subject to thermal expansion and contraction. Provide combination deflection/expansion couplings for rigid metallic and non-metallic conduits where such conduits cross through building expansion joints.
- J. Provide full wall steel flexible conduit for all conduit penetrations through fire walls. Full wall steel flexible conduit shall be 3-hour through penetration fire wall rated.
- K. Provide necessary sleeves and chases where conduits and cables pass through floors, walls, ceilings, and roofs, and provide other necessary openings and spaces, all arranged for in proper

time to prevent unnecessary cutting. Perform cutting and patching in accordance with the provisions for the original work.

- L. Provide offsets prior to entrance into outlet boxes and other electrical equipment for proper adjustment to finished building surfaces. Exercise care when roughing-in conduits which turn up or down to surface mounted panelboards or cabinets, so that conduit extensions to cabinet will be fitted close to wall. Where possible, provide back entry into surface mounted boxes or equipment items.
- M. Install rigid galvanized steel conduit with ends cut square without sharp edges, threaded, and I.D. reamed to remove any burrs. Field made bends shall be of equivalent radius as factory made bends. Exposed threads shall be kept to a minimum.
- N. Install conduit sealing fittings and conduit seals for work in classified locations in accordance with NEC requirements for Class 1, Division 1 and Class 1, Division 2 locations.
- Q. Feeder and branch circuit conduits shall not be run below concrete slabs or in concrete slabs unless specifically indicated so on the drawings, or unless there is no other way to feed the outlet, device, or equipment.
 - 1. Where conduits are run underground below concrete slabs they shall be kept a minimum of 12" below bottom of slab. Provide rigid steel conduit for horizontal and vertical sweeps below concrete floor slabs and for penetrations through concrete floor slabs.
 - 2. Where conduits turn out of concrete slab in open areas, provide threaded couplings flush with floor line for extending exposed conduit to equipment, outlet, fitting or box.
- R. Carefully clean and dry all conduit before installation of conductors. Do not pull wires into conduit system until building roof and walls are weather-tight and all rough plastering is completed. Provide Prime Conduit conduit plugs and end caps to exclude dust, moisture, plaster, or mortar while building is under construction.
- S. Lubricants or cleaning agents which might have deleterious effect on conductor coverings shall not be used for drawing conductors into raceways.
- T. Provide minimum 3/16 inch diameter twisted nylon fish cord in all empty raceways. Provide tag on each end indicating location of other end. Fish cord shall have minimum of 200 pounds tensile strength.
- U. All wiring shall be installed in electrical metallic tubing unless otherwise specified herein or called for on the drawings.

3.3 SLEEVES:

- A. Provide EMT sleeves for each conduit and cable passing through walls, partitions, and floors.
 - 1. Set pipe sleeves in place before wall, floor, or partition is finished.
 - 2. Support conduit and cable free from sleeves.

3. Provide sleeves two pipe sizes larger than the conduit or cable passing through, or provide a minimum of ½” clearance.

3.4 CONDUCTOR INSTALLATION:

A. General:

1. The interior of all conduits shall be cleared of burrs, moisture, dirt and obstructions before wires are pulled.
1. Lubricant for pulling wires shall be inert to cable and conduit, shall not in any way restrict ease of pulling through conduit with passage of time, and shall be special lubricant designed specifically for cable pulling and shall be chemically compatible with cable.
2. Emergency circuit wiring shall be kept entirely independent of all other wiring in accordance with NEC Article 700.10(B).

B. Color Coding:

1. Consistent phase identification of all conductors shall be maintained as follows:

	<u>120/208V</u>	<u>277/480V</u>
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral Wire	White	Natural Gray

Provide colored plastic tape of specified color code identification for large size conductors available only in black. Wrap tape three complete turns around conductor, at ends and at connections and splices. Provide same color coding for switch legs as corresponding phase conductor.

C. Minimum Conductor Sizes:

1. The minimum branch circuit conductor size shall be #12AWG. Provide #10AWG conductors for branch circuits where the conductor run exceeds 75 feet, and #8AWG conductors where the conductor run exceeds 150 feet.

- D. Provide the number of conductors required for a given branch circuit, or as required for circuitry, whether indicated on the drawings or not.

E. Neutral Conductors:

1. All branch circuits shall be installed with a separate neutral conductor. Shared neutrals for groups of branch circuits shall not be permitted.

- F. Provide each circuit with a dedicated ground wire back to its respective panel ground bar. Size all ground wires in accordance with NEC requirements. Use #12AWG minimum size.
- G. Identify conductors passing through pull boxes, junction boxes, and wireways to indicate circuit designation. Identify pull boxes and junction boxes as specified herein.
- H. Phase conductors shall be connected to phase supply mains in proper rotation to assure balanced condition on panel. Circuit numbers assigned on drawings are for convenience only. Provide typed circuit directories for all panelboards at conclusion of work, representing circuits as actually connected to panelboard. Directories shall note the equipment, devices and rooms served by each branch circuit.
- I. Branch circuit wiring and arrangement of home runs have been designed for maximum economy consistent with adequate sizing for voltage drops, circuit ampacities and other considerations.
 - 1. Install the wiring with circuits arranged as shown on the drawings, except as otherwise approved in advance by the Engineer.
 - 2. Do not make changes and rearrange circuits without prior approval.
 - 3. If more than 3 current carrying conductors are installed in one conduit they shall be derated in accordance with the National Electric Code. Do not install more than three 30 Amp single phase or four 20 Amp single phase circuits in the same conduit. Do not run emergency and normal power wiring in the same conduit.
- K. Splices and Connections:
 - 1. Make splices electrically and mechanically secure with pressure-type connectors.
 - a. For wires size #8AWG and smaller, provide solderless, screw-on connectors, 600V rating, of size and type to manufacturer's recommendation, with temperature ratings equal to the conductor insulation.
 - b. Make splices and terminations to conductors #6AWG and larger with corrosion-resistant, high conductivity, pressure indent, hex screw or bolt clamp connectors, with or without tongues, designed specifically for intended service. Connectors for cables 250 kcmil and larger shall have two clamping elements or compression indents. Terminals for bus connections shall have two bolt holes. Splitbolt connectors, Burndy, IlSCO or Greaves, shall be acceptable for all splices of conductors #6AWG and larger.
 - 2. Insulate splices with a minimum of two layers of all weather, heavy duty, abrasion resistant, 8.5 mil thick, 105 degree C. rated vinyl electrical tape where insulation is required. Tape splices 1 ½ times the thickness of the conductor insulation.
 - 3. Provide high conductivity copper alloy bolt-on lugs with pressure plate and socket set screw or hex head screw to attach wire and cable to disconnect switches, transformers, and other electrical equipment as required.

4. Provide cable reducing adaptor plugs where required for terminating oversize cable to standard size equipment lugs. Conductor strands shall not be cut in order to fit equipment lugs.
5. Provide antioxidant joint compound for all conductor connections.

3.5 OUTLET BOXES:

- A. Install outlet boxes at uniform heights and straight and true with reference to walls, floors, ceilings and casework.
- B. Provide knockout plugs in boxes with unused openings.
- C. Secure all outlet boxes to building structure with metal straps, rods, or bolts independently of entering conduits or cables.

3.6 PULL BOXES AND JUNCTION BOXES:

- A. Provide pull boxes and junction boxes where shown on the plans and where required to facilitate proper pulling of wires and cables. Install pull boxes no less than one every 100 ft. of straight horizontal conduit run, or three 90 degree bends, unless otherwise noted.

3.7 WIRING DEVICES:

- A. Wherever possible install switches directly adjacent to the strike side of door. Check architectural drawings for door swing.
- B. Device mounting heights indicated below are general. Refer to drawings for special cases.

Receptacles	1'-6" AFF to bottom of device.
Switches	4'-0" AFF to top of device.

- C. Install receptacles vertically with grounding posts at top of device, except locate grounding post to left for horizontal mounting.

3.8 MOTOR POWER AND CONTROL WIRING:

- A. Contractor shall provide and be responsible for the complete power wiring of all motors and motorized equipment.
- B. Furnish proper overload and short circuit protection for all new motors. Provide a combination thermal overload and disconnect switch for all equipment using fractional horsepower motors.
- C. Check electrical connections and sizing of motor circuit protection and prevent damage to motor and equipment from incorrect direction of rotation.

- D. Provide mounting for motor and equipment disconnect switches adjacent to motor and supported independent of motor.
- E. Provide interlock wiring where required for motors and controllers, whether shown on the drawings or not.
- F. Connections to miscellaneous building equipment:
 - 1. Wire to and connect to, all items of building equipment not specifically described in this Section but to which electrical power is required.
 - 2. Coordinate as necessary with other trades and suppliers to verify types, numbers and locations of equipment.

3.10 GROUNDING SYSTEM:

- A. Provide a complete grounding system which will thoroughly ground the non-current carrying metal parts of every piece of installed equipment, as described herein and as indicated on the drawings.
- B. System shall be mechanically and electrically connected to provide an independent return path to the grounding sources.
- C. Each grounding conductor shall have a minimum capacity of 25 percent of the rated capacity of the equipment it grounds, unless otherwise indicated.
- D. The minimum size of grounding conductors shall be No. 12 AWG copper. Insulation color of grounding conductors shall be green.
- E. Provide insulated throat grounding bushings at all feeder conduit connections to switchgear, panelboards, transformers, disconnect switches, wireways, and pull boxes. Connect grounding bushings within each enclosure, backbox, or pull box by #4 AWG bare copper bonding conductor connected to a grounding lug welded to the enclosure, backbox, wireway, or pull box.
- F. Provide a separate green ground conductor for each feeder and branch circuit.
- G. Grounding of Motors: Motors shall be grounded by connecting a green covered conductor from a grounding bushing in the starter to the motor frame. Conductor shall be installed in the conduit with the circuit conductors and terminated in the motor connection box, providing the terminal is mechanically connected to the frame. If this is not feasible, grounding conductor from the starter shall be extended through an insulated bushed opening in the connection box and connected to motor base.
- H. Tests: Entire system shall be thoroughly tested on completion for ground continuity and capacity. Provide not more than 10 ohms resistance between main ground system and equipment frame system neutral and/or derived neutral point.

3.11 SPECIAL REQUIREMENTS:

- A. Wiring shall be bundle tied where passing through pull boxes, wireways, and panelboards in neat and orderly manner with plastic cable ties. Cable ties shall be Ty-Raps as manufactured by Thomas & Betts, or comparable product in 3M or Leco Plastics manufacture.
- B. Turn branch circuit and auxiliary system wiring out of wiring gutters at 90 degrees to circuit breakers and terminal lugs.
- C. Provide miscellaneous hardware and support accessories, including channels, unistrut, jack chain, support rods, nuts, bolts, screws, and other such items, with galvanized or cadmium plated finish, or other approved rust inhibiting coatings.
- C. Unload electrical equipment and materials delivered to site. Pay cost for rigging, hoisting, lowering and moving electrical equipment on site, in building or on roof. During construction, provide additional protection against moisture, dust accumulation and physical damage of electrical equipment. Provide temporary heaters within units, as approved to evaporate excessive moisture and provide ventilation as required.

3.12 TESTING AND INSPECTION:

- A. Provide personnel and equipment, make required tests, and secure required approvals from the governmental agencies having jurisdiction.
- B. When material and/or workmanship is found to not comply with the specified requirements, within three days after receipt of notice of such non-compliance remove the non-complying items from the job site and replace them with items complying with the specified requirements, all at no additional cost to the Owner.
- C. Perform all required adjustments and settings. Verify and coect deficiencies as necessary including voltages, tap settings, trip settings and phasing of equipment from distribution system to point of use.
- D. Provide all necessary testing equipment.
- E. Test wiring, buswork, and connections for continuity and ground by “megger” test. Minimum insulation resistance between conductors and ground shall be as follows:
 - 1. For circuits of #14 or #12 AWG wire: 1,000,000 ohms.
 - 2. Conductor current carrying capacities from 25 to 50 amperes, inclusive: 250,000 ohms.
 - 3. Conductor current carrying capacities from 51 to 100 amperes, inclusive: 100,000 ohms.
 - 4. Conductor current carrying capacities from 101 to 200 amperes, inclusive: 50,000 ohms.
 - 5. Conductor current carrying capacities from 201 to 400 amperes, inclusive: 25,000 ohms.
 - 6. Conductor current carrying capacities from 401 to 800 amperes, inclusive: 12,000 ohms.
 - 7. Conductor current carrying capacities over 800 amperes: 5,000 ohms.

Submit "megger" test results to the Engineer for review.

- F. Main ground electrode system shall not exceed 10 ohms unless specified otherwise.
 - 1. Verify ground resistance by ground continuity test between main ground system and equipment frame system neutral and/or derived neutral point.
 - 2. Perform ground continuity test by passing minimum of ten Amps DC between ground reference system and ground point. Calculate resistance by voltage drop method.
- G. In the Engineer's presence:
 - 1. Test all parts of the electrical system and prove that all such items provided under this Section function electrically in the required manner.

3.13 PROJECT COMPLETION:

- A. Upon completion of the work of this Section, thoroughly clean all exposed portions of the electrical installation, removing all traces of soil, labels, grease, oil and other foreign material, and using only the type cleaner recommended by the manufacturer of the item being cleaned.
- B. Vacuum all exteriors and interiors of switchboards, panelboards, transfer switches, safety switches, and equipment racks to remove all dust, dirt, cable clippings, etc.
- C. Equipment with damage to painted finish shall be repaired to satisfaction of the Owner.
- D. On the first day the facility is in operation, for at least eight hours, at a time directed by the Owner provide a qualified foreman and crew to perform such electrical work as may be required by the Owner.
- E. Thoroughly instruct the Owner's operation and maintenance personnel in the contents of the operations and maintenance manual required to be submitted under these Specifications.

END OF SECTION 26 05 00

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including Division 0, Contract Requirements, and Division 1, General Requirements, are a part of this Section and shall be binding on the Contractor and /or Subcontractor who performs this work. Note also all addenda.
- B. Sections 26 00 00 General Electrical and 26 05 00 Basic Electrical Materials & Methods shall also govern the work under this Section.
- C. This Section includes requirements that are binding on other Sections of Divisions 26.
- D. Examine all drawings, data, and coordinate the work of this Section with all related and adjoining work.

1.2 SCOPE OF WORK:

- A. Scope of work consists of installation of materials to be furnished under this Section, and without limiting generality thereof consists of furnishing labor, materials, equipment, hoisting, plant, transportation, rigging, staging, appurtenances, and services necessary and/or incidental to properly complete all electrical work as shown on the drawings, as described in these specifications or as reasonably inferred from either as being required in opinion of the Engineer.
- B. Work Included: Provide complete electrical services where shown on the drawings, as specified herein and as needed for a complete and proper installation including but not necessarily limited to:
 - 1. General
 - 2. Equipment Labeling
 - 3. Wire and Cables
 - 4.. Cabinets
 - 5. Supporting Devices
 - 6. Grounding

1.3 QUALITY ASSURANCE:

- A. Refer to Section 26 00 00.
- B. The manufacturer shall be a company specializing in the manufacture of medium voltage cable and/or accessories with minimum five years documented experience in producing cable and/or accessories similar to those specified below.
- C. The cable materials and manufacture shall meet or exceed all applicable requirements of the latest editions of ICEA Standard S-93-639, UL 1072 and NEMA standards.
- D. The cable shall be manufactured using a triple extrusion process in which the conductor shield, insulation, and insulation shield are installed at essentially the same time without an intervening storage period on reels or other storage devices.

- E. The Contractor shall be a company with experience in the installation of medium voltage cable and accessories. The electricians performing the work shall be experienced in medium voltage cable installation. Workmen involved in splicing and termination of cables shall have been specifically trained in the procedures required for the splices and terminations used in this project. At the discretion of the Engineer, documentation of experience and/or training in medium voltage cable splicing and termination shall be furnished by the Contractor.

1.4 SUBMITTALS:

- A. Shop Drawings, Product Data, and Certifications that products conform to specified requirements. Submit for all items provided as part of the Work of this Section.
- B. Submit product data indicating cable and accessory construction, materials, ratings, and all other parameters identified in Part 2 - Products below.
- C. Submit manufacturer's installation instructions.
- D. Submit manufacturer's certificate stating approval for field acceptance testing per National Electrical Testing Association standards (at least 35 kV DC for 5 kV rated cable and 64 kV DC for 15 kV rated cable).
- E. Submit manufacturer's certificate stating that medium voltage cable meets or exceeds all requirements specified below.

1.5 PROJECT RECORD DOCUMENTS:

- A. Accurately record exact sizes, lengths, types, locations, and quantities of cables. Also show where all splices are located for each cable.

1.6 DELIVERY, STORAGE, AND HANDLING:

- A. Cable shall be stored according to manufacturer's recommendations as a minimum. In addition, cable must be stored in a location protected from vandalism and weather. If cable is stored outside, it must be covered with opaque plastic or canvas with provision for ventilation to prevent condensation and for protection from weather. If air temperature at cable storage location will be below 32 degrees F., the cable shall be moved to a heated (50 degrees F minimum) location. If necessary, cable will be stored off site at the Contractor's expense.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Provide only materials that are new and of type and quality specified, or approved equal. Where Underwriters' Laboratories, Inc. have established standards for such materials, provide only materials bearing the UL label.
- B. Provide materials and equipment necessary to make installation complete in every detail, and to conform to manufacturers' latest installation instructions, under this contract whether or not specifically shown on drawings or specified herein.
- C. All cable shall be new, delivered to the site, and be less than two years since manufacture. It shall be from manufacturer's stock; not suppliers' warehouse stock. Manufacturer's certification of factory test values shall be submitted for all cable furnished. All specified dimensions are nominal.

- D. Provide an insulated copper ground conductor in all conduits with medium voltage cable. This ground conductor shall be the same size as the phase conductors.

2.2 MEDIUM VOLTAGE CABLE - SHIELDED:

- A. Cable: Single conductor, insulated cable rated 5 KV, 133% insulation level, ungrounded, NEC-UL Type MV-105. Sizes as indicated on the Drawings.
- B. Conductor: Soft copper, annealed, uncoated, Class B compressed, compact, or concentric stranded, having nominal direct-current resistance equal to or less than that required in section 2.4.1 or 2.4.2 and Table 2-2 of ICEA S-93-639.
- C. Conductor shield: extruded semiconductor with resistivity requirements of section 3.3 of ICEA S-93-639 for discharge-free designs and nonconducting high permittivity compound for discharge-resistant designs. Material shall be clean stripping from the conductor and firmly bonded to the overlying insulation.
- D. Insulation: Extruded EPR (ethylene propylene rubber), rated at 5 KV, 133 per cent insulation level, nominal thickness of .115 inches.
- E. Insulation Shield: The insulation shield shall consist of an extruded semiconducting layer directly over the insulation and a copper tape over the semiconducting covering. The tape shall be at least 5 mils (0.127 mm) thick and be spiral wrapped with a minimum 12.5 per cent overlap. The insulation shield shall meet all requirements of section 5 of ICEA S-93-639.
- F. Jacket: Polyvinyl Chloride (PVC), black color with a jacket thickness meeting all requirements of ICEA S-93-639.
- G. Cable Rating: Continuous duty at 105 degrees C., wet or dry locations, suitable for underground duct installations, UL type MV-105.

2.3 CABLE TERMINATIONS:

- A. Modular Molded Shrink Type Termination: IEEE 48; Class 1; 5 KV. Kit form, suitable for use with cable specified, including slip-on type flexible skirted polymer or silicon rubber insulator. All terminations shall be skirted type. Termination shall be hot or cold shrink type with internal stress relief tube to distribute electric field (10% to 90% equipotential lines) over entire length of skirted insulator.
- B. Submittal for approval shall show electric field distribution (via equipotential lines) of termination device.
- C. Lugs shall be copper, long barrel, two hole or four hole and rated for the voltage applied. The lugs shall match the pads on the equipment to which the cable will be mounted.
- D. If there will be more than one cable on an equipment pad approved spiders (or spacers) must be used. Cable attachment to equipment must match the equipment manufacturers UL labeling requirements (if the equipment is UL Listed) as a minimum. Unless the equipment is designed or listed for it, cable lugs may not be placed back to back on the equipment pad. In all cases, the termination and equipment must be taped with approved anti-tracking tape.

2.4 CABLE SPLICES:

- A. Modular Molded Shrink Type Splice: IEEE 404-1986; Class 1; 5 KV. Kit form, suitable for use with cable specified, including slip-on type flexible polymer or silicon rubber insulator. Splice shall be hot or cold shrink type with internal stress relief tube to distribute electric field (10% to 90% equipotential lines) over entire length of insulating material.

- B. Molded body shall contain a built-in internal semiconducting layer which covers and contacts the splice barrel and the cable insulation layer to prevent electrical stress buildup inside the body. This semiconducting layer shall be bonded to and covered with a cured EPDM rubber or polymer insulating layer which, in turn, shall be bonded to and covered with a semiconducting layer and metallic shield and jacket.
- C. Splicing sleeves shall be long barrel type and rated for the voltage applied.
- D. The completed splice shall be approved for underground direct burial and water immersion service.
- E. Submittal for approval shall show electric field distribution (via equipotential lines) of termination device.

2.5 CABLE LABELING:

- A. Cable labels shall be engraved, laminated plastic plates suitable for use from -40 deg. F. to 150 deg. F., and shall be resistant to oil, water and solvents. Nameplate shall be minimum size 1-1/2" X 4". Face shall be white and the letters shall be black. Fasten label to cable with nylon tie-wraps. See paragraphs below for information type and label locations.

PART 3 - EXECUTION

3.1 CABLE PULLING:

- A. Prior to pulling cable, a mandrel/swab 1/4 inch smaller than the duct diameter shall be pulled through duct run to insure adequate opening of duct run. Thoroughly swab conduits to remove foreign material before pulling cables.
- B. Cables shall not be pulled from an outdoor (exterior) location when the outdoor (exterior) air temperature is below 32 degrees F.
- C. Contractor shall furnish all required installation tools to facilitate cable pulling without damage to the cable jacket. Such equipment is to include, but be not limited to, sheaves, winches, cable reels and/or cable reel jacks, duct entrance funnels, pulling tension gauge, and similar devices. All equipment shall be of substantial construction to allow steady progress once pulling has begun. Makeshift devices which may move or wear in a manner to pose a hazard to the cable shall not be used.
- D. Cable ends shall be sealed and firmly held in the pulling device during the pulling operation.
- E. Cable pulling shall be done in accordance with cable manufacturer's recommendations, except as modified herein, and ANSI/IEEE C2 standards. Manufacturer's recommendations shall be a part of the cable submittal. Recommended pulling tensions shall not be exceeded. Pulling bending radius shall not be less than that determined by the manufacturer or the NEC. Restrictions of pulling bending radius dimensions shall be strictly observed. Training bending radius shall not be less than 12 times cable diameter. Any cable bent or kinked to radius less than recommended dimension shall not be installed.
- F. Actual pulling tensions shall be continuously monitored and permanently recorded in a log and submitted to the Engineer at the end of the project.
- G. During pulling operation an adequate number of persons shall be present to allow cable observation at all points of duct entry and exit as well as to feed cable and operate pulling machinery.
- H. Pulling lubricant shall be used to ease pulling tensions. Lubricant shall be water or silicone based of a type which is noninjurious to the cable material used. Wax based lubricants are not allowed. Lubricant shall not harden or become adhesive with age.

- I. Avoid abrasion and other damage to cables during installation.
- J. Where cables are left in manhole or switchgear overnight or more than 8 hours prior to termination, the cable ends shall be sealed with paraffin or shrink wrap caps and supported in a manner which will prevent entrance of moisture into the cable. Cable shall be terminated and energized as soon as possible.

3.2 CABLE ROUTING SWITCHGEAR:

- A. Cables within switchgear shall be routed in a manner which will allow adequate room for bending and terminating cables. Cables must be secured in a manner which will not result in cable weight being placed on the termination electrical joint. Cable support shall be made in a manner that does not force cable against grounded metal or which compresses cable diameter. Cable training bending radius shall be at least 12 times cable diameter. Any cable bent to a radius less than recommended dimension will not be accepted.

3.3 SPLICES AND TERMINATIONS INSTALLATION:

- A. Splices are to be held to a minimum. Splice locations shall be determined by cable lengths available, pulling conditions and termination points. Splice locations are to be listed by the Contractor prior to cable purchase and a listing of such locations submitted to the Engineer for approval before final cable lengths are determined.
- B. Only experienced electricians shall be employed in this phase of the work. Refer to **QUALITY ASSURANCE** above.
- C. Follow cable manufacturer's and splice or termination manufacturer's installation instructions and ANSI/IEEE C2 standards.
- D. Clean, white lint-free gloves shall be used to handle end of cable during tape wrapping procedures.
- E. Termination or splicing of the copper conductors (both power and ground conductors) shall be made only with tool applied compression (swaged) fittings.
- F. Ground system connections:
 - Cable to bus: compression cable fitting bolted to bus with lock washers under nut.
 - Cable to ground rod: approved bolted fitting with backing plate between cable and rod.
 - Ground cable shield at each termination and splice.
- G. Splice or termination failure upon high potential acceptance test will require complete reconstruction of the joint to manufacturer's specifications. Make sure that there is enough free cable at each termination or splice for two more terminations or splices to be performed.
- H. Install Scotch #70 tape for anti-tracking on all exposed terminations.
- I. All splices and terminations are to be tagged using embossed plastic tags with plastic attachment devices indicating date splice or termination was made, name of electrician involved, name of Contractor installing cable, feeder number and circuit to and from data.
- J. Lugs shall be bolted to termination pads in equipment using corrosion resistant bolts, nuts, and washers. Use Belleville washers for bolting aluminum to aluminum, and lock washers for bolting copper to copper or as recommended by equipment manufacturer. Torque to manufacturer's recommendations.

3.4 FIREPROOFING OF MEDIUM VOLTAGE CABLES:

- A. Exposed cables in cable trays shall be fireproofed. Additionally, cables shall be fireproofed in pull boxes, troughs, switchgear pull sections and pulling pits containing two or more sets of cable. Entire installation shall conform to manufacturer's recommendations.
- B. Arc proofing material shall be Scotch #77 electrical arc and fireproofing tape, or approved equal.
- C. Install the fireproofing on the cables as follows:
- D. Install tightly applied fireproofing tape, approximately 1/16 inch thick by 1-1/2 inches wide minimum, around each feeder spirally in one half-lapped wrapping.
- E. Install the tape with the coated side towards the cable and extend it not less than one inch into each duct.
- F. Install random wrappings of Scotch #69 glass cloth tape around the installed fire proofing tape per manufacturer's instructions to prevent it from unraveling.

3.5 CABLE ACCEPTANCE TESTS:

- A. Acceptance tests will be performed by an independent Testing Consultant under separate contract with the Owner. The Contractor shall coordinate the scheduling of the tests and provide labor and services necessary to allow the Testing Consultant to test each completed cable circuit. This includes opening and closing equipment, providing temporary light and power as needed, etc.
- B. Acceptance tests will be performed on all cable after installation and prior to energization. All splices and terminations are to be completed and tested as part of the acceptance test.
- C. In the event that test results are not satisfactory, the Contractor shall make repairs and replace components as necessary to correct faults. Following corrections, tests will be repeated to the extent required to prove the deficiencies are corrected.

3.6 CABLE IDENTIFICATION AND LABELING:

- A. Provide the following information on cable identification label:

Main feeder circuit number

To and From Data

EXAMPLE:

FDR: 1
TO: ACADEMIC HALL
FROM: MH P25

- B. Install cable labels on each conductor at each cable termination, each cable splice, in each manhole and in each pullbox. Additionally, at these locations, provide one inch (1") colored vinyl plastic electrical tape wrap identification, (Scotch 35 or approved equal) around each conductor and cable as follows:
 - 5 KV individual conductor system
 - A - phase - one (1) yellow wrap
 - B - phase - two (2) yellow wraps with 1/2" space between wraps
 - C - phase - three (3) yellow wraps with 1/2" space between wraps
- C. See paragraph above under **SPLICES AND TERMINATIONS INSTALLATION** for splice label requirements. This is in addition to identification labels.
- D. During entire cable installation, phasing of conductors shall be maintained and identified. Where final connections to equipment are made, phasing shall be verified and proper phase rotation determined prior to connection.

END OF SECTION 26 05 13

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including Division 0, Contract Requirements, and Division 1, General Requirements, are a part of this Section and shall be binding on the Contractor and /or Subcontractor who performs this work. Note also all addenda.
- B. Section 26 00 00 General Electrical
Section 26 05 00 Basic Electrical Materials & Methods
Section 26 05 13 Medium Voltage Cables
Section 26 10 00 Medium Voltage Switchgear

1.2 SCOPE OF WORK:

- A. The electrical contractor shall retain the services of an independent third party firm, or the equipment manufacturer's technical services group, to perform a short circuit/coordination study and arc flash risk assessment as described herein.
- B. Preliminary studies shall be submitted to the A/E prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture to ensure the characteristics and ratings of the proposed overcurrent devices will be satisfactory. The final submittal shall capture any changes in circuit lengths, wire sizes, additional loads, etc. that may occur during the construction.
- C. The studies shall include all portions of the electrical distribution system from the normal power source or sources, and emergency/standby sources, down to and including the smallest circuit breaker in the distribution system (for short circuit calculations). Normal system connections and those which result in maximum fault conditions shall be adequately covered in the study.
- D. The firm should be currently involved in medium- and low-voltage power system evaluation. The study shall be performed, stamped and signed by a registered professional engineer in the State of Wisconsin. Credentials of the individual(s) performing the study and background of the firm shall be submitted to the A/E for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.
- E. The firm performing the study should demonstrate capability and experience to provide assistance during start up as required.
- F. The study and assessment shall be performed on SKM Dapper, Captor and PowerTool software or EasyPower product suite software.

1.3 QUALITY ASSURANCE:

- A. Refer to Section 26 00 00.

1.4 REFERENCE STANDARDS:

- A. Standards listed in the IEEE “Buff Book”, latest edition
National Fire Protection Association (NFPA) 70E, latest addition
IEEE 1584 – Guide for Performing Arc Flash Calculations

1.5 DATA COLLECTION FOR THE STUDY:

- A. The contractor shall obtain and provide the required data for preparation of the studies.
- B. The contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

1.6 SUBMITTALS:

- A. **THIRD PARTY QUALIFICATIONS**
Submit qualifications of individual(s) who will perform the work to the A/E for approval prior to commencement of the studies.

- B. **PRELIMINARY REPORT**
Submit a draft of the studies to the A/E for review prior to delivery of the final study to the Owner. Make all additions or changes as required by the reviewer.

For building construction projects, submit a draft of the studies to the A/E for review prior to A/E approval of project electrical switchgear, panelboard and generator shop drawings.

- C. **FINAL STUDY REPORT**
Provide studies in conjunction with equipment submittals to verify equipment ratings required.

The results of the power system studies shall be summarized in a final report and provided in the following formats. Provide (2) bound hard copies of the final report. Provide (2) electronic copies (on CD) of the final report and one-line diagrams in PDF format. Provide (2) electronic copies (on CD) of the final report in MS Word format and the one-line diagrams in CAD format.

Also provide (2) electronic copies (on CD) of all files generated by the SKM or EasyPower software for all scenarios evaluated in the studies. The files shall permit the studies to be opened, reviewed or updated by any user of the analysis software used for the studies.

The report shall typically include the following sections:

- I. Overview
- II. Short Circuit Study
 - SC-1 Purpose
 - SC-2 Explanation of Data

- SC-3 Assumptions
- SC-4 Analysis of Results
- SC-5 Recommendations
- SC-6 Fault Analysis Input Report from Software Program
- SC-7 Fault Contribution Report
- III. Protective Device Coordination Study
 - PDC-1 Purpose
 - PDC-2 Explanation of Data
 - PDC-3 Assumptions
 - PDC-4 Analysis of Results
 - PDC-5 Recommendations (Including NEC 700-27 Requirement)
 - PDC-6 Results from Software Program
 - PDC-7 Example Drawings
- IV. Arc Flash Study
 - ARC-1 Purpose
 - ARC-2 Explanation of Data
 - ARC-3 Assumptions
 - ARC-4 Analysis of Results
 - ARC-5 Recommendations
 - ARC-6 Arc Flash Evaluation Report from Software Program
- V. Prioritized Recommendations and Conclusions
- VI. Appendices
 - APP-1 One-line Diagrams from Software Program
 - APP-2 AutoCAD One-line Diagrams
 - APP-3 Protective Device Summaries from Software Program
 - APP-4 Reference Data
 - APP-5 Sample Work Permit Form
 - APP-6 Copy of Warning Labels, including study date

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 SHORT CIRCUIT AND COORDINATION STUDY:

- A. The short circuit, coordination, and arc flash hazard studies shall be performed using SKM Dapper, Captor and PowerTool for Windows software or EasyPower product suite Windows based software packages. In the short circuit study, provide calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data including power company system characteristics, typical calculations, and recommendations. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault at each supply switchgear lineup, unit substation primary and secondary terminals, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, and other significant locations throughout the system. Provide a ground fault current study for the same system areas, including the associated zero sequence impedance data. Include in

tabulations fault impedance, X to R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault currents.

- B. In the protective device coordination study, provide time-current curves graphically indicating the coordination proposed for the system, centered on conventional, full-size, log-log forms. Include with each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered by that particular curve sheet. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.
- C. Include on the curve sheets power company relay and fuse characteristics, system medium-voltage equipment relay and fuse characteristics, low-voltage equipment circuit breaker trip device characteristics, pertinent transformer characteristics, pertinent transformer characteristics, pertinent motor and generator characteristics, and characteristics of other system load protective devices. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in each motor control center, and main breaker in branch panelboards.
- D. Include all adjustable settings for ground fault protective devices. Include manufacturing tolerance and damage bands in plotted fuse characteristics. Show transformer full load and 150, 400, or 600 percent currents, transformer magnetizing inrush, ANSI transformer withstand parameters, and significant symmetrical and asymmetrical fault currents. Terminate device characteristic curves at a point reflecting the maximum symmetrical or asymmetrical fault current to which the device is exposed.
- E. Select each primary protective device required for a delta-wye connected transformer so that its characteristic or operating band is within the transformer characteristics, including a point equal to 58 percent of the ANSI withstand point to provide secondary line-to-ground fault protection. Where the primary device characteristic is not within the transformer characteristics, show a transformer damage curve. Separate transformer primary protective device characteristic curves from associated secondary device characteristics by a 16 percent current margin to provide proper coordination and protection in the event of secondary line-to-line faults. Separate medium-voltage relay characteristic curves from curves for other devices by at least a 0.4-second time margin.
- F. Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors, or generators as noted on drawing one-lines.
- G. Utilize equipment load data for the study obtained by the Contractor from contract documents, including contract addendums issued prior to bid openings.
- H. Include fault contribution of all motors in the study. Notify the Engineer in writing of circuit protective devices not properly rated for fault conditions.
- I. Provide settings for the chiller motor starters or obtain from the mechanical contractor, include in the study package, and comment.

- J. When an emergency generator is provided, include phase and ground coordination of the generator protective devices, to meet NEC 700.27 requirements. Show the generator decrement curve and damage curve along with the operating characteristic of the protective devices. Obtain the information from the generator manufacturer and include the generator actual impedance value, time constants and current boost data in the study. Do not use typical values for the generator.
- K. Evaluate proper operation of the ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided, and discuss the neutral grounds and ground fault current flows during a neutral to ground fault.
- L. For motor control circuits, show the MCC full-load current plus symmetrical and asymmetrical of the largest motor starting current to ensure protective devices will not trip major or group operation.

3.2 FIELD SETTINGS:

- A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study, protective device coordination study and arc flash risk assessment.
- B. Necessary field settings and adjustments of devices and minor modifications to equipment to accomplish conformance with the approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the owner.

3.3 ARC FLASH RISK ASSESSMENT:

- A. As part of the short circuit and coordination study, arc flash risk assessment shall be included. The study shall include the following:
 - 1. Determine and document all possible utility and generator/emergency sources that are capable of being connected to each piece of electrical gear. Calculations shall be based on highest possible source connection.
 - 2. Calculations to conform to National Fire Protection Association (NFPA) 70E recognized means of calculation standards. All incident energy units shall be calculated in calories per square centimeter.
 - 3. Provide recommended boundary zones and personal protective equipment (PPE) based on the calculated incident energy and requirements of NFPA 70E for each piece of electrical gear.
- B. Electrical Contractor shall provide warning labels as required by OSHA based upon the results of the arc flash risk assessment. At a minimum, the labeling shall contain the following information: nominal system voltage, arc flash boundary, limited approach boundary, restricted approach boundary, available incident energy and the corresponding working distance or the arc flash PPE category, minimum arc rating of clothing, and study date. Label shall also include the name or logo and the phone number of the company performing the study.

- C. Arc flash warning labels shall be affixed to all electrical equipment that is likely to require examination, adjustment, servicing or maintenance while energized. This includes, but is not limited to, medium-voltage switchgear, transformers, switchboards, panel boards, three-phase disconnect switches, transfer switches, motor control centers, motor controllers, and three-phase motor disconnect switches.

END OF SECTION 26 05 73

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. The General Provisions of the Contract, including Division 0, Contract Requirements, and Division 1, General Requirements, are a part of this Section and shall be binding on the Contractor and /or Subcontractor who performs this work. Note also all addenda.
- B. Section 26 00 00, General Electrical, shall also govern the work under this Section.
- C. Section 26 05 00, Basic Electrical Materials & Methods, includes requirements that are binding on this Section.
- D. Examine all drawings, data, and coordinate the work of this Section with all related and adjoining work.

1.2 SUMMARY

- A. This specification section describes all labor, materials, equipment and services necessary for and incidental to furnishing the newly manufactured switchgear and control system required for the system specified herein.
- B. The Switchgear Manufacturer shall manufacture and furnish all equipment as described in this section of the specification. All equipment shall have a practical layout, consistent with good engineering design practices and all for future expansion capability.
- C. The Switchgear Manufacturer's scope of work shall also include factory testing and comprehensive system site start-up and testing.
- D. Wherever the terms “plans” or “drawings” are used in these specifications, they shall refer to the Bid Documents for this project. These drawings, together with this specification and other related documents, make up the Contract Documents. The equipment proposed under these specifications shall be compatible with the space provisions and wiring configurations shown on these drawings.

1.3 REFERENCE STANDARDS

- A. The design, equipment, installation, and testing shall be in strict accordance with the applicable requirements set forth in ANSI, UL, IEEE and NEMA.
- B. The generator switchgear construction, including all internal components mounted, shall be UL listed and labeled under “Circuit Breakers and Metal-Clad Switchgear over 600 Volts (DLAH)” at the time of the bid opening. Manufacturers submitting equipment line-ups without being listed and labeled under UL (DLAH) prior to bid opening shall not be accepted.

- C. The entire Critical Power Switchgear System, including all controls, breakers, buswork and components shall be completely manufactured and assembled by a single manufacturer and shall be UL listed and labeled under this manufacturer's name.
- D. All equipment and material supplied shall be in accordance with the latest edition and amendments of all applicable standards, codes, laws and regulations listed below:
1. IEEE 1547 - Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
 2. ANSI/IEEE C12 – Code for Electric Metering
 3. ANSI C37.04 – Standard Rating Structure for AC High Voltage Circuit Breaker Rated on a Symmetrical Current Basis.
 4. ANSI C37.06 – Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breaker Rated on a Symmetrical Current Basis.
 5. ANSI C37.11 – Requirements for Electrical Control for AC High Voltage Circuit Breaker Rated on a Symmetrical Current Basis or a Total Current Basis.
 6. ANSI C37.12 – Guide to Specifications for AC High Voltage Circuit Breaker Rated on a Symmetrical Current Basis or a Total Current Basis.
 7. ANSI C37.20.2-2015 – IEEE Standard for Metal-Clad Switchgear.
 8. ANSI/IEEE C39.1 - Requirements for Electrical Analog Indicating.
 9. ANSI C57.13 - Requirements for Instrument Transformers.
 10. ANSI 255.1 - Gray Finishes for Industrial Apparatus and Equipment.
 11. ANSI 48 – Test Procedures and Requirements for High-Voltage AC Cable Terminations
 12. NFPA 70 - National Electric Code.
 13. NFPA 110 - Emergency and Standby Systems.
 14. National Electrical Code (NEC)
 15. Underwriters’ Laboratories, Inc. (UL)
 16. National Electrical Manufacturers’ Association (NEMA)
 17. Federal, State and local codes.

1.4 STRUCTURAL PERFORMANCE REQUIREMENTS

The medium voltage switchgear shall have a seismic certification, based on shaker table testing, and certified in accordance with IBC, CBC and ICC-ES AC156.

1.5 SWITCHGEAR MANUFACTURER QUALIFICATIONS

- A. It is the intent of the owner to receive bids only from Russelectric who will provide complete engineering, manufacturing production, testing and field services to manufacture and provide a highly reliable, fully integrated, state-of-the-art Critical Power Switchgear System that can be successfully supported by the Switchgear and Controls Manufacturer over the lifetime of the system.
- B. Russelectric must have trained, factory employed, field service personnel on staff for installation support and start-up and to provide field support for the life of the system. Factory field service engineers shall be readily available twenty-four hours a day, 365 days a year. The manufacturer may not subcontract field service work or personnel. A 24 hour, toll free "Hot-Line", with a guaranteed call back response within 1 hour, from a qualified factory technician must be in place at the time of bid offering with a proven history of response.

1.6 SUBMITTALS

- A. Furnish a submittal with adequate information to fully define the system offered.

Information that shall be submitted by the Switchgear Manufacturer as itemized below:

- 1. A one-line diagram clearly indicating the functional relationship between equipment.
- 2. Outline drawings showing plan and elevation views of each piece of equipment, and containing the following information for each item:
 - a) Size.
 - b) Weight.
 - c) Dimensions and weight of the equipment shipping splits.
 - d) Typical conduit entry areas
- 3. Detailed cubicle front view drawings, equipment door detail drawings showing all meter, annunciator and control device locations with nameplate legends, with all required nameplate information
- 4. Base plans for the location of the equipment floor channels, anchor bolts and conduit entrance spaces,
- 5. Catalog data sheets for all circuit breakers and protective devices.
- 6. Short-circuit rating of bus, and interrupting and withstand ratings of breakers.
- 7. Detailed bill of material indicating items to be released first, due to long lead time.
- 8. System delivery schedule.
- 9. Proposed sequence of operation for entire system.
- 10. A statement listing all deviations and/or exceptions to these specifications.

Two copies of the reviewed submittal approved and stamped by the consulting engineer will be returned to the Switchgear Manufacturer for production release.

1.7 OPERATION AND INSTRUCTION MANUALS

- A. The Switchgear Manufacturer shall submit a complete hard copy and two CD versions of O&M manuals two weeks after conclusion of the equipment start-up and final acceptance.

These manuals shall include, but not be limited to, the following items:

1. Detailed operating and maintenance instructions.
 2. All approved "As-Built" shop drawing information shall be updated to "As-Installed" and include all field modifications.
 3. Assembly splice-plate details for interconnection of shipping sections.
 4. Wiring diagrams for each breaker, switch, etc., with all terminal markings and connections for other circuits.
 5. Internal connection diagrams of relays, instruments and control switches.
 6. Complete parts list with all principal parts identified as to manufacturer and type or model number.
 7. Recommended spare parts list (with pricing) for one-year operation.
 8. Hard copy of the equipment PLC program (bound separately).
 9. Complete system interconnect diagrams
- B. Maintenance: The manufacturer shall provide an optional, comprehensive preventive maintenance program.
- C. Prior to training owner personnel, a set of complete O & M manuals shall be delivered to the Owner.
- D. O & M manuals shall contain 100% accurate system "As-Installed" drawings, interconnect diagrams, schematic diagrams, wiring diagrams, individual sub-system component manuals, operation procedures, system description with theory of operation, maintenance schedules and procedures, original programmed settings and parameters, and all other information necessary for the Owner to maintain, operate, test, and troubleshoot the system.
- E. O & M manuals shall not solely rely on sub-component manuals. A thorough consolidation of operation and maintenance information shall be available in a system overview guide. All major components of the system such as breakers, synchronizers, generator cubicle control, genset controls, PLC, Operator interface touch screen, and Master Cubicle shall be included in this overview.

1.8 WARRANTY

- A. The Manufacturer shall provide a comprehensive two-year warranty that includes all parts and labor to repair or replace any defects that may appear within the two-year period, from date of shipment. All parts, labor and transportation costs to remedy any defect or failure to comply with the contract documents shall be provided by the manufacturer and corrected at no cost to the owner.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Subject to compliance with requirements specified herein, provide products by the following manufacturer:

Russelectric, South Shore Park, Hingham, Massachusetts
No Other Manufacturers Allowed

2.2 SYSTEM OVERVIEW

- A. Furnish the distribution switchgear, arranged for the distribution of power to a new 1500-Ton Chiller.
- B. The emergency switchgear shall be 3 phase, 3 wire.
- C. All control voltage for circuit breakers shall be obtained from the 48 VDC station battery as further specified in Article 2.08.G.
- D. Provide required modifications to the Russelectric Medium Voltage Utility/Generator Paralleling Switchgear SO 29597.
- Provide a (1) Square D MV Breaker type VRO CIRCUIT BKR, VACUUM, 1200A, 15.0KV MAX. 250MVA,ELECTRICALLY OPERATED, WITH 3A & 4B AUX SWITCHES,125VDC CHARGE/CLOSE & TRIP W/ SPR CHG to be installed in an existing cradle as listed below:

Switchgear Serial/SWBD	Cell	Breaker Type	Breaker Frame	Voltage Class	Breaker Model	Breaker Serial Number	Other
29597-P-2	D8	Distribution	1200A	5 kV			52-18

- Breakers will be provided to match the existing operations such as; electric or manual breaker operation, charge coil voltage, close coil voltage, trip coil voltage and all wiring for secondary connections will be designed to match the existing switchgear specifications.
- Provide PLC Logic and SCADA modifications to:
- Add D8 breaker, 52-18, to the switchgear controls.
- Add D8 breaker, 52-18, to the load controls (load shed and load adds).

2.3 SEQUENCE OF OPERATION

- A. All system operation and control functions shall be coordinated and integrated such that during automatic and/or manual operation, no unsafe condition shall occur, no malfunction of intended operation shall occur, and the highest possible reliability of operation shall be maintained.
- B. Coordinate and integrate the functions and circuitry of all selector switches to ensure that the various settings available do not cause a malfunction of the intended system operation.

2.4 LOAD CONTROL CIRCUITS

- A. Provide control circuits, interlocks, and relays to protect against overloading.

2.5 CIRCUIT BREAKERS

- A. All circuit breakers shall be Square D type VRO and of the horizontal drawout type, with self-aligning line-side and load-side disconnecting devices. Primary disconnecting contacts shall be silver-plated copper.
- B. All circuit breakers shall be of equal rating and shall be interchangeable. The circuit breakers shall be rated as follows:
- Nominal voltage rating of 4160 volts .
 - Continuous current rating of 1200 amperes elements shall be supplied, as indicated on the drawings and detailed elsewhere in this specification.
 - Nominal 3 phase symmetrical interrupting capability of 25 KA with interrupting time not more than 3 cycles.
- C. Each circuit breaker shall contain three vacuum interrupters, separately mounted in a self-contained, self-aligning housing that can be removed as a complete unit. The interrupters shall be designed to facilitate the following work:
- Replacement of the interrupter assembly through a simple alignment of the primary contacts and adjustment of contact wipe.
 - Measurement of available contact life by referring to a contact wear gap indicator for each vacuum interrupter, which requires no tools to operate and is easily visible when the breaker is withdrawn on extension rails.
- D. The circuit breaker shall be equipped with tinned-plated secondary contacts that automatically engage in the breaker operating position and can be manually engaged in the breaker test position.
- E. The breaker shall be operated via a spring-charged, stored energy system with an automatic electric recharging motor. The mechanism shall always store sufficient energy to insure a trip open operation. Trip, close and spring charge control power shall be 48 VDC derived from the Critical Power Switchgear Station Battery System.
- F. All circuit breakers shall be equipped with minimum of four sets of breaker auxiliary (a/b) contacts with the final number required to be determined by the Switchgear Manufacturer. Trip and close/spring charge control power fuse blocks shall be provided.
- G. All circuit breakers shall have circuit breaker status annunciator lights as detailed elsewhere in this specification. The circuit breaker annunciator shall be a group of three, individual 1.0" x 1.0" (minimum) back lit LED annunciators with engraved marking plates as follows:
- Circuit breaker open.
 - Circuit breaker closed.

Circuit breaker withdrawn.

- H. In addition to monitoring the breaker position and availability, the system PLCs shall also monitor the following:
- Circuit breaker disconnected
 - Protective relay trip
 - Control voltage failure
 - Springs not charged
 - Failure of breaker trip or close circuitry
- I. Interlocks: Provide mechanical interlock to prevent removal or insertion of breaker while in the closed position. Provide interlock on breaker that automatically discharges closing springs upon removal from or insertion into compartment.

2.6 CONTROL AND SAFETY DEVICES

- A. Current Transformers: 0-5 ampere output, wound type, molded construction, with single secondary winding and primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices. Rated 50-400 Hertz, 600 volts at 10 kV BIL full wave and built to ANSI/IEEE C57.1.3 and UL in accordance with IEC 44-1.
- B. Potential Transformers: 120 volt single secondary, with primary fusing and secondary circuit breaker protection, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.
- C. Protective Relaying: All protective relaying shall be utility grade with drawout case or provided with CT and PT test switches to isolate the relays from the PTs and CTs for testing. The protective relays shall be separate and independent from all other controllers including the PLC control system and the engine mounted controls.

2.7 INSTRUMENT AND CONTROL WIRING

- A. Instrument and control wiring within the switchgear sections shall be of flame-retardant, type SIS, extra-flexible, tinned copper, rated 600 volts and approved for switchgear use.
- B. Control wiring shall be protected with individual circuit breakers with trip indication, monitored by the system PLC and alarmed on the OIP and logged in the event log.
- C. All wire terminations made at meters, relays CTs and PTs and other similar devices shall be made with ring-tongue or locking-spade crimp lugs or as required by the device termination point.
- D. All terminations shall be clearly identified by means of heat embossed vinyl sleeve markers at each end. Labeling tape, or paper, wire markers are not acceptable. Wire numbers shall match the Manufacturer's interconnection, schematic and wiring drawings.

- E. Terminal blocks shall utilize “Cage-Clamp” technology and shall be clearly marked for wiring to be installed or reconnected by the Contractor. All connections between shipping sections shall utilize plug connections to reduce installation time.
- F. Cage Clamp terminal blocks that provide high clamping force, maintenance free terminations shall be provided for secondary wire terminations.
- G. All current transformers shall be connected to shorting type mechanical, lever arm switches with test points. Current transformer secondary wiring shall be #12 AWG.
- H. Control wiring shall be labeled at each terminal point, with designations keyed to wiring diagrams.

2.8 SWITCHGEAR CONSTRUCTION

- A. The medium voltage switchgear shall be designed for operation at 4160 volt, three phase, three wire and 60 Hz.
- B. The switchgear shall be arranged as shown on the drawings. Shipping splits shall be provided as determined during the approval meeting with the Approving Authority.
- C. The assembled switchgear structures shall be designed for the following insulation levels:
 - 1. Maximum design voltage of 4.76 kV.
 - 2. Insulation test (60 Hz) of 19 kV.
 - 3. Full-wave impulse test of 60 kV BIL.
- D. Compartments: Switchgear compartments shall be constructed as follows:
 - 1. All compartments and major components of the primary circuits, such as circuit breakers, transformers and bus, shall be completely enclosed within grounded metal barriers, isolating secondary control devices and their wiring from all high voltage primary devices.
 - 2. Power circuit breakers shall be installed in individual front compartments with separate doors. The breaker compartments shall have grounded metal safety shutters that automatically cover the primary breaker connections when the breaker is removed. The breaker compartment shall have a racking mechanism to move the breaker from operating to drawout positions. The mechanism shall automatically align the breaker and hold it rigid in the operating position. The safety shutters shall be driven by the racking mechanism.
 - 3. Potential transformer compartments shall have drawout tray type construction. Power connections shall be automatically disconnected when the tray is drawn out.
 - 4. The main bus shall be fully compartmented. Access plates to the bus compartment shall be located in the rear of the switchgear.
- E. Enclosures: The metal-clad switchgear enclosures shall be fabricated as follows:
 - 1. Freestanding, floor mounted, indoor type.

2. Dead front, dead rear.
3. Fabricated on a die-formed steel base or base assembly, welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting.
4. Die-pierced holes for connecting adjacent sections to assure alignment and facilitate future additions.
5. Bolts, nuts and Belleville spring washers of zinc-plated metal.
6. Designed to withstand the electrical and mechanical stresses occurring during operation of the assemblies.
7. Framework formed of code gauge steel (12 gauge minimum), suitable for anchorage to the floor.
8. Metal-clad construction, with rugged steel assemblies featuring bracing, reinforcing gussets and jig-welding, to assure rectangular-rigidity.
9. Open bottom sections, as required for ready installation and termination of conduits.
10. Removable side, top, front and back panels, attached by bolts and small enough for easy handling by one person.
11. Front and rear hinged, cubicle doors
12. Individual front doors for each power circuit breaker compartment.
13. Suitable means near the top and bottom of each switchboard to insure adequate ventilation for all equipment within the switchboard assembly.

F. Busses:

1. All busses shall be 4160 volt, three-phase, three-wire, 60 Hertz.
2. All busses and stub connections shall be copper.
3. All busses shall be insulated by means of flame-retardant, track resistant epoxy insulation.
4. The continuous ampere rating of all power bus shall be *1200* amperes. Busses shall be sized such that the current density is not greater than the current carrying capacity of the rectangular copper bars, as required by UL and NEMA standards. Heat rise tests shall be conducted in accordance with ANSI C37.55. Buses and stub connections shall limit temperature rise to 30 degrees C at load current capacity and an ambient temperature of 40 degrees C.
5. A ground bus rated 25% of the current-carrying capacity of the switchgear main bus shall extend across the entire width of each switchgear assembly.
6. Nominal bus bracing capacity shall be equal to or greater than the interrupting rating of the highest rated breaker serving the bus. Minimum bus bracing shall be 25 KA symmetrical. Each bus connection to the breakers shall match the frame size of the circuit breaker to which the bus is connected.
7. Bus bar and interconnection joints shall be *silver* plated, constant-high-pressure type, with Grade 5 steel, zinc plated bolts, nuts and Belleville spring washers.
8. Bus phase designations from front to back, top to bottom, left to right shall be A, B, C, respectively, when viewed from the front.

G. Dimensions:

1. The switchgear framework shall conform to the arrangements and details shown on the drawings, and to the space designated for installation.
2. The highest operating handles shall not appear higher than 6' 6" above the floor.

3. Adequate clearance shall be allowed to permit good accessibility of feeder conductors and bus terminations for maintenance purposes.
- H. Finish: All steel parts shall be prepared for painting by a five (5)-step cleaning, phosphatizing and sealing process. The parts shall then be painted ANSI 61 gray, utilizing polyester powder coat applied by the electrostatic method and cured in a baking oven. This finish shall be suitable for outdoor, as well as indoor applications and have a corrosion resistance per ASTM B117 for 1000 hours, minimum.
- I. Nameplates:
1. Externally visible, permanent nameplates shall be provided on the switchgear and control cubicle doors to identify each instrument, instrument switch, meter, protective relay, control switch, indicating light, circuit breaker compartment, etc. Relays shall be designated as to use, and as to the phase to which they are connected.
 2. Nameplates shall be laminated plastic, attached with bolts. Characters shall be white engraved on a black background.
 3. Equipment (i.e. relays, timer, PLC equipment, etc.) and terminal blocks within the switchgear compartments shall be suitably identified by labeling tape with thermally embossed text.
- J. Miscellaneous:
1. The system controls shall utilize heavy-duty industrial grade, controls and relays. All synchronizing and failure circuit relays shall embody the fail safe principle of dual contacts in parallel.
 2. The switchgear manufacturer shall be responsible for providing the coordinating wiring diagrams showing the electrical connections between the control switchgear and the engine generators, for use by the Electrical Contractor and engine generator service personnel during installation and checkout of the equipment.
 3. Provide a floor portable, manually operated circuit breaker hoist for removal/transporting of a circuit breaker element and or trunion rollout assembly

2.9 EQUIPMENT DESCRIPTION

A. Main Breaker and PT Cubicle

The Main Breaker cubicle shall be metal-clad and furnished with the following basic components, and any additional equipment necessary to provide for a complete and dependable system.

- One 4160V, vacuum circuit breaker, 3 phase, 1200 amperes, stored energy, draw out type, arranged for operation on 48 VDC control powerTwo sets of (2) potential transformers, roll-out type, with required primary and 120 volt secondary
- Two sets of (3) current transformers, ratio as required, for metering, relaying, etc. One set shall be dedicated for differential relaying

- One set current transformers, supplied loose for mounting in generator terminal box, as required for differential relaying
- One multi-function generator protection relay, Schweitzer model 700G (ANSI devices #87, #81O/U, #50/51V, #51G, #46, #40, #32 and #27/59)
- One lockout relay, Electroswitch Type LOR (ANSI device #86)
- One circuit breaker control switch, with a separate back-lit L.E.D. annunciator for circuit breaker status indications (circuit breaker opened, circuit breaker closed, circuit breaker withdrawn). Annunciator shall match the other annunciators and be as specified herein
- One lamp test pushbutton
- A set of compression lugs for customer's generator connections
- One set of three insulated boots for lug connections, each boot capable of handling up to 3 lugs, for use by the electrical contractor to eliminate the need for taped connections
- A set of 3 phase, 1200 amperes, insulated copper bus and ground bus shall be furnished as required for main bus and breaker connections
- Control wiring, DC circuit breakers, fuses, fuse blocks, WAGO terminals, nameplates, etc, as required. All wiring to be labeled at both ends with tubular sleeve, permanent wire markers.

B. Distribution Breaker Cubicles

Each distribution feeder breaker cubicle shall be metal-clad and furnished with the following basic components, and any additional equipment necessary to provide for a complete and dependable system.

- (2) Two 4160V vacuum circuit breakers, 3 phase, 1200 amperes, stored energy, draw out type, arranged for operation on 48VDC control power
- Two sets of (3) current transformers, ratio as required, for metering, relaying, etc.
- Two, three phase overcurrent and ground overcurrent relays, Schweitzer model 751 (ANSI device 50/51 and 51N),
- Two lockout relays, Electroswitch Type LOR (ANSI device #86)
- Two circuit breaker control switches, with a separate back-lit L.E.D. annunciator for circuit breaker status indications (circuit breaker opened, circuit breaker closed, circuit breaker drawn out). Annunciators shall match the other annunciators and be as specified herein
- One lamp test pushbutton
- Two sets of compression lugs shall be provided for each breaker, for power cable connections
- Two sets of three insulated boots for lug connections, each boot capable of handling up to 3 lugs, for use by the electrical contractor to eliminate the need for taped connections
- A set of 3 phase, 1200 amperes, insulated copper bus and ground bus shall be furnished as required for main bus and breaker connections
- Control wiring, DC circuit breakers, fuses, fuse blocks, WAGO terminals, nameplates, etc, as required. All wiring to be labeled at both ends with tubular sleeve, permanent wire markers.

C. Station Battery and Battery Charger

A station battery shall be furnished for the Switchgear and Control System. The station battery shall be installed on a freestanding, two tiered seismic rated, battery rack with spill containment. Operation shall be completely automatic with the charger maintaining the battery fully charged under all normal service conditions. Cooling shall be by convection.

A wall-mounted battery charger enclosure shall be equipped with the following:

- (a) A DC voltmeter, DC ammeter, float-charged indicator and high-rate charge indicator shall be mounted on the front of the panel.
- (b) The enclosure shall contain a potentiometer for adjusting float charge voltage and a potentiometer for adjusting the high-rate voltage. These controls shall be equipped with AC and DC fuses and an AC and DC failure alarm relay.
- (c) An automatic, 24-hour timer shall be installed within the console cabinet. Following an AC power failure longer than 8 to 12 seconds, the timer shall automatically switch the charger to the high-rate mode. After the preset interval, the timer shall return the battery to float charge.

The storage batteries shall be a sealed lead-antimony or selenium, alkaline type, manufactured by ALCAD. The battery shall be designed for nominal 48 volt DC switchgear service and shall be capable of delivering 50-ampere-hour capacity at the 8-hour rate.

The battery charger shall be of the constant-potential, two-rate type with a regulated output voltage stability of +/- 1% from zero to full nominal current rating, over an input voltage variation of 10%. Input shall be 120 volts, 60 Hertz, single phase, AC. Nominal output shall be 25 amperes and 48 volts DC.

- D. The contractor shall provide all required low voltage DC wiring from the battery charger to the battery station and from the battery station to the switchgear C/B's.

PART 3 - EXECUTION

3.01 COORDINATION

- A. The Switchgear Manufacturer shall be responsible for providing the coordinating interconnect diagrams showing the electrical connections between all related equipment specified this section of the specifications. The interconnect diagrams are for use by the Electrical Contractor and switchgear service personnel during installation and checkout of the equipment.
- B. The Switchgear Manufacturer shall verify the completion of all start-up commissioning and site testing of the Critical Power Switchgear System.
- C. The Electrical Contractor shall be responsible for obtaining and providing any required power coordination /arc flash study and furnishing a copy of the approved study to the switchgear manufacturer's start-up field engineer prior to the commencement of the switchgear startup procedures.

3.02 FACTORY TESTING

- A. At the factory, the Switchgear Manufacturer shall perform tests on the switchgear and generator controls as required verifying the proper operation of each component and demonstrating full compliance with the requirements of this specification. The factory test reports will be available upon request.
- B. The equipment shall be completely assembled, wired, adjusted, and tested at the factory. Rigid inspections before and after assembly shall assure correctness of design and workmanship. After assembly, each switchgear assembly shall be tested for operation under simulated conditions.
- C. After a visual inspection, the following operational tests shall be performed:
 - 1. Operate all circuit breakers in connected as well as in test positions. Check the operation of all interlocks by attempting to close breaker into interlocked configurations.
 - 2. Check racking mechanisms by removing and reinstalling each circuit breaker.
 - 3. Check stored energy mechanism of each breaker by tripping, closing and tripping each breaker after removal of control power.
 - 4. Dielectric tests.
 - 5. Test all protective relay devices by simulation tests.
- D. The Manufacturer shall supply all equipment, devices and circuitry required to simulate all synchronizing and paralleling functions, digital and analog signal inputs, outputs and confirmation signals, diesel generator control and operation. Automatic and manual operation of the paralleling circuit breakers and protective and indicating devices shall be included.

3.03 PACKING AND SHIPPING

- A. The Switchgear Manufacturer shall prepare all equipment covered by this specification in such a manner as to protect it against damage in transit.
- B. The Switchgear Manufacturer shall perform the following steps to prepare the equipment for shipping and final assembly at the site:
 - 1. All equipment shall be adequately packed to prevent damage from handling, weather, shock, vibration and corrosion during shipment by common carrier.
 - 2. All metering and equipment shall be protected to ensure cleanliness during shipment, storage and erection.
 - 3. Each item of equipment shall be clearly marked. All boxes, crates and shipments shall be numbered and identified with the following information:
 - a) Owner's purchase order number.
 - b) Owner's name and delivery location.
 - c) Manufacturer's name and address.
 - d) Contents.
 - 4. All equipment shall have provisions for lifting and skidding. All lifting points shall be clearly marked.

5. Each shipping unit shall be braced adequately and rigidly both internally and externally to prevent damage during transit or in the process of erection.
 6. When assemblies are supplied that require disassembly for installation or are shipped disassembled, each piece of the subassembly so affected shall be uniquely identified as to its assembly position. All loose peripheral equipment shall be boxed, crated or otherwise completely enclosed and protected during storage, handling and shipment.
- C. All equipment and material shall be shipped to the job site unless otherwise instructed.
- D. All equipment shall be adequately protected, braced and secured to prevent physical and environmental damage during transit and handling. All material not mounted or installed on the major equipment during shipping shall be properly crated and shipped with the associated equipment.
- E. Drawout circuit breakers shall be crated and shipped separately if recommended by the breaker vendor otherwise breakers will be shipped within the system.
- F. The Vendor shall coordinate shipping of all equipment and material with the successful Contractor.
- G. Shipping sections shall be arranged to permit transport through limited access as required.
- H. The equipment shall be equipped for handling by crane, pallet jack and rollers.

3.04 INSTALLATION

- A. The Electrical Contractor shall provide labor and materials for the installation of the Critical Power Switchgear System plus all associated external wiring for power and controls including all battery station wiring. All rigging required for unloading and installation shall be the responsibility of the Electrical Contractor.
- B. The Switchgear shall be installed following the procedures set forth by the Switchgear Manufacturer. The Switchgear Manufacturer shall assist the Electrical Contractor as required in interpreting the installation instructions. The Electrical Contractor shall certify to the Switchgear Manufacturer and Owner that the installation has been performed per the latest documents and instructions.
- C. Following installation, the Switchgear Manufacturer shall inspect and verify the correct installation of the switchgear, including all individual components.

3.05 FIELD SERVICE AND START-UP TRAINING REQUIREMENTS

- A. The Switchgear Manufacturer shall provide the services of a field service engineer for a pre-installation coordination meeting with the Electrical Contractor to coordinate the installation and interconnection of the Critical Power Switchgear System and generators.
- B. The Switchgear Manufacturer shall provide a field engineer for an initial visit to checkout the installation of the switchgear to allow the energization of the utility main service breaker if required.

- C. The Switchgear Manufacturer shall provide a field engineer for post installation start-up and testing assistance, prior to system turnover and initial instruction and training for the facility's operating personnel. This trip shall include all service required to checkout the Critical Power Switchgear System and demonstrate the complete operation for final acceptance by the owner.

- D. At the time of start-up of the system equipment, the Switchgear Manufacturer shall furnish (2) preliminary sets of installation, operating and maintenance manuals. At the conclusion of the site testing, the field engineer shall leave (1) manual at the site. This manual shall include any and all changes that have occurred during the equipment start-up. The amended manual shall serve as a reference tool until the final sets of O&M manuals are supplied.

- E. The instructions shall include recommended field test procedures as defined in the Standards. A schedule listing the frequency prescribed for performing the field tests shall be provided.

- F. Approximately six months after the complete system turnover, a visit shall be made to provide instruction for operating personnel on the complete operation and maintenance program for the Critical Power Switchgear System.

- G. The bid shall include the cost for the services of a factory authorized service representative to train the Owner's On-Site Work Force (OSWF) on procedures and schedules for programming, setting of relay, startup, shutdown, troubleshooting, servicing and preventive maintenance of all equipment. Included below:
 - 1. The instruction shall be dedicated and intensive and shall be provided by competent instructors fully familiar with the equipment.
 - 2. The instructions shall be presented in an eight hour session. The Field Service engineer will provide Instructions on the operation and maintenance of the switchgear, circuit breaker, protective relays and PLC equipment.
 - 3. The Owner will provide a suitable classroom environment on site for the instruction session.
 - 5. The training session may be recorded by the owner.
 - 6. Training to be scheduled with at least seven working days advance notice.
 - 7. Provide both classroom training and hands-on equipment operation covering the following:
 - a. Safety precautions.
 - b. Features and construction of switchgear and accessories.
 - c. Routine inspection, test and maintenance procedures.
 - d. Routine cleaning.
 - e. Features, operation and maintenance of protective devices.
 - f. Interpretation of readings of indicating and alarm devices.
 - g. Review operating and maintenance manuals.
 - h. Review troubleshooting operations.

END OF SECTION 26 10 00

1.01 RELATED DOCUMENTS:

- A. The General Provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this Section.
The General Requirements in Section 26 00 00 shall also govern the work under this Section.
- B. The General Requirements in Section 23 05 00 shall also govern the work under this Section
- C. Examine all drawings and data and coordinate the work of this section with all related equipment and adjoining work.

1.02 DESCRIPTION

- A. This specification is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.
- B. The drive manufacturer shall supply the drive and all necessary options as specified. All drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). Drives that are manufactured by a third party and “brand labeled” shall not be acceptable.
- C. This specification is intended to supplement a drive schedule. The drive schedule identifies the optimized BOM for the project and includes quantity, size, voltage, enclosure rating, options, and harmonic mitigation requirements of the drives. IEEE 519-2014 is an electrical system standard for harmonic mitigation and not intended to be applied to an individual piece of equipment. The EOR (Engineer of Record) has determined all drives provided on this project shall be active front end drives, thus confirming that the drives will not take the electrical system out of IEEE 519-2014 compliance.

1.03 QUALITY ASSURANCE

- A. Referenced Standards and Guidelines:
 - 1. Institute of Electrical and Electronic Engineers (IEEE)
 - a. IEEE 519-2014
 - 2. Underwriters Laboratories (as appropriate)
 - a. UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995
 - 3. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA)
 - a. NEMA ICS 7-2014, Adjustable Speed Drives
 - 4. International Electrotechnical Commission (IEC)
 - a. EN/IEC 61800
 - 5. National Electric Code (NEC)
 - a. NEC 430.120, Adjustable-Speed Drive Systems

6. CSA Group
 - a. CSA C22.2 No. 274
 7. International Building Code (IBC)
 - a. IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156
- B. Qualifications:
1. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer's guidelines.
 2. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).
 3. The base drive shall be seismically certified per 2018 International Building Code (IBC) with a seismic importance factor of 1.5, and minimum 2.5 S_{DS} rating. Seismic certification of equipment and components shall also be provided by OSHPD preapproval.
 4. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50% for up to 0.2 seconds, sags to 70% for up to 0.5 seconds, and sags to 80% for up to one second.
 5. Acceptable Manufacturers

1.04 SUBMITTALS

- A. Submittals shall include the following information:
1. Outline dimensions, conduit entry locations and weight.
 2. Customer connection and power wiring diagrams.
 3. Complete technical product description include a complete list of options provided. **Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.**
 4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
 - a) The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, **no exceptions.**

1.05 WARRANTY:

- A. Provide a minimum of 24 month warranty on all parts and labor specified under this section with start date of owner's acceptance of job. The warranty shall include all parts, labor, and associated costs incurred by the manufacturer to provide factory authorized on-site service

PART 2 – PRODUCTS

2.01 MANUFACTURERS:

- A. ABB

2.02 VARIABLE FREQUENCY DRIVES

- A. The drive package as specified herein and defined on the drive schedule shall be enclosed in a UL Type enclosure.
- B. The drive shall provide full rated output from a line of +10% to -15% of nominal voltage across an ambient temperature range of -15 to 40° C (5 to 104° F).
- C. All drives shall utilize the same Advanced Control Panel (keypad) user interface.
 - 1. Plain English text
 - a. The display shall be in complete English words for programming and fault diagnostics.
 - b. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch or vibration trip. Customized terms, such as: AHU-1 End Switch or CT-2 Vibration shall also be available.
 - 2. The control panel shall include at minimum the followings controls:
 - a. Four navigation keys (Up, Down, Left, Right) and two soft keys.
 - b. Hand-Off-Auto selection, Fault Reset, and manual speed control.
 - c. A Help key shall include assistance for programming and troubleshooting.
 - 3. There shall be a built-in time clock in the control panel with 10-year battery backup.
 - 4. I/O Summary display with a single screen shall indicate and provide:
 - a. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs.
 - b. The function of all analog inputs, analog outputs, digital inputs, and relay outputs.
 - c. The ability to force all inputs and outputs to either a high, low, or specific value.
 - 5. The drive shall automatically backup parameters to the control panel. The drive shall allow two additional unique manual backup parameter sets to be stored.
 - 6. The control panel shall be removable, capable of remote mounting.
 - 7. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.
 - a. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard.
 - b. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameters.
 - c. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.
- D. All drives shall have the following hardware features/characteristics as standard:
 - 1. Two (2) programmable analog inputs, two (2) programmable analog outputs, six (6) programmable digital inputs, and three (3) programmable Form-C relay outputs.
 - 2. The drive shall include an isolated USB port for interface between the drive and a laptop.
 - 3. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.

4. Harmonic mitigation hardware shall be provided to limit the current distortion to 3% total harmonic current distortion, when measured at the lugs of the drive. The harmonic mitigation hardware shall be internal to the drive package and include the following characteristics:
 - a. An IGBT based active front end shall be used for mitigation of low frequency harmonics. A LCL filter shall be installed in front of the IGBTs to remove high frequency harmonics.
 - b. The drive shall provide full motor nameplate voltage while operating the motor at nameplate RPM. The output IGBTs must be modulating and in control of the motor during this 100% speed/load operating condition. The specified 3% current distortion and 1.0 displacement power factor shall be achievable during this operating condition.
 - c. The hardware structure of the front end shall boost the DC bus voltage by 10% during low line conditions.
 - d. Displacement power factor shall be 1.0 throughout the speed range.
 - e. The combined harmonic content of all the drives on the project must be small enough to not interfere with an emergency generator's voltage regulator. Drives capable of regeneration shall not be allowed on applications with a generator.
 5. The drive shall have variable speed primary cooling fans.
 6. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute.
 7. The input current rating of the drive shall not be greater than the output current rating.
 8. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
 9. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4th Edition.
 10. The drive shall include a robust DC bus to provide short term power-loss ride through. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.
- E. All drives shall have the following software features as standard:
1. A Fault Logger that stores the last 16 faults in non-volatile memory. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
 2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault.
 3. Programmable start methods: Flying-start, Normal-start, and Brake-on-start.
 4. Programmable loss-of-load (broken belt / coupling) indication. This function to include a programmable time delay to eliminate false loss-of-load indications.
 5. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in "Watts."
 6. There shall be a run permissive circuit for damper or valve control.
 7. Four separate start interlock (safety) inputs shall be provided. The control panel will display the specific safety(s) that are open.

8. The drive shall include a switching frequency control circuit that reduces the switching frequency based on actual drive temperature. It shall be possible to set a minimum and a target switching frequency.
9. The ability to automatically restart after non-critical faults.
10. PID functionality shall be included in the drive.
11. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source.
12. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
13. The drive shall include a fireman's override mode.

F. Security Features

1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
2. The drive shall include password protection against parameter changes. There shall be multiple levels of password protection including: End User, Service, Advanced, and Override.
3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive.
4. The "Hand" and "Off" control panel buttons shall have the option to be individually disabled (via parameter) for drives mounted in public areas.

G. Network Communications

1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP and LonWorks shall be available. Coordinate with the local BMS.
2. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card based protocol.
3. The drive shall not require a power cycle after communication parameters have been updated.
4. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later.

H. Disconnect – A circuit breaker or disconnect switch shall be provided when indicated on the drive schedule. The disconnect shall be door interlocked and padlockable. Drive input fusing shall be included on all packaged units that include a disconnecting means. All disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

I. Bypass – Bypass drive packages shall be provided when indicated on the drive schedule. All drive/bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. The drive and bypass package shall be a complete factory wired and tested bypass system consisting of a padlockable disconnect device, drive output contactor, bypass contactor, and drive input fuses.

2. The bypass control shall be powered by a three-phase switch mode power supply with a voltage tolerance of +30%, -35%. Single-phase power supplies and control power transformers (CPT) are not acceptable.
3. The drive and bypass package shall be seismic certified and labeled to the IBC with a seismic importance factor of 1.5. Seismic certification shall include OSHPD preapproval.
4. All bypass packages shall utilize a LCD bypass control panel (keypad) user interface. The bypass control panel must be a separate display from the drive control panel.
5. All bypasses shall have the following hardware features/characteristics as standard:
 - a. Six (6) digital inputs and five (5) Form-C relay outputs.
 - b. Drive isolation fuses shall be provided. Bypass designs which have no such fuses, or that only incorporate fuses common to both the drive and the bypass are not acceptable.
 - c. The bypass shall be able to detect a single-phase input power condition while running in bypass, disengage the motor, and provide a single-phase input power indication.
 - d. The bypass shall be designed for stand-alone operation and be completely functional in both Hand and Automatic modes, even if the drive and/or drive's control board has failed.
6. All bypasses shall have the following software features as standard:
 - a. Programmable loss-of-load (broken belt / coupling) indication shall be functional in drive and bypass mode.
 - b. Run permissive and start interlock control functionality shall be functional in bypass mode.
 - c. The bypass control shall monitor the status of the drive and bypass contactors and indicate when there is a welded contactor contact or open contactor coil.
 - d. The bypass shall include a selection for either manual or automatic transfer to bypass.
 - e. The drive and bypass shall be designed to operate as an integrated system when in Override mode. There shall be four selectable Override modes: Bypass only, drive only, drive then transfer-to-bypass upon fault, and force to stop.
7. Network communications – the bypass shall include BACnet MS/TP, Modbus, and Johnson Controls N2 as standard. Optional communication cards for BACnet/IP and LonWorks shall be available.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.
- B. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. Caution: VFDs supplied without internal reactors have substantially higher input current ratings, which may require larger input power wiring and branch circuit protection. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.02 START-UP

- A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

3.03 PRODUCT SUPPORT

- A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.
- B. Provide 2 – 4 hour on-site training sessions for the Owners personnel. Training sessions shall be conducted on separate days at the Owners convenience. The training shall include installation, programming and operation of the VFD, bypass and serial communication. Owner training shall be provided locally upon request.

END OF SECTION 26 29 23

